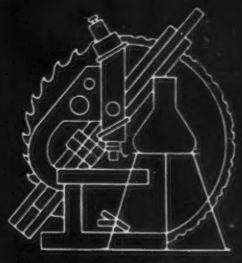
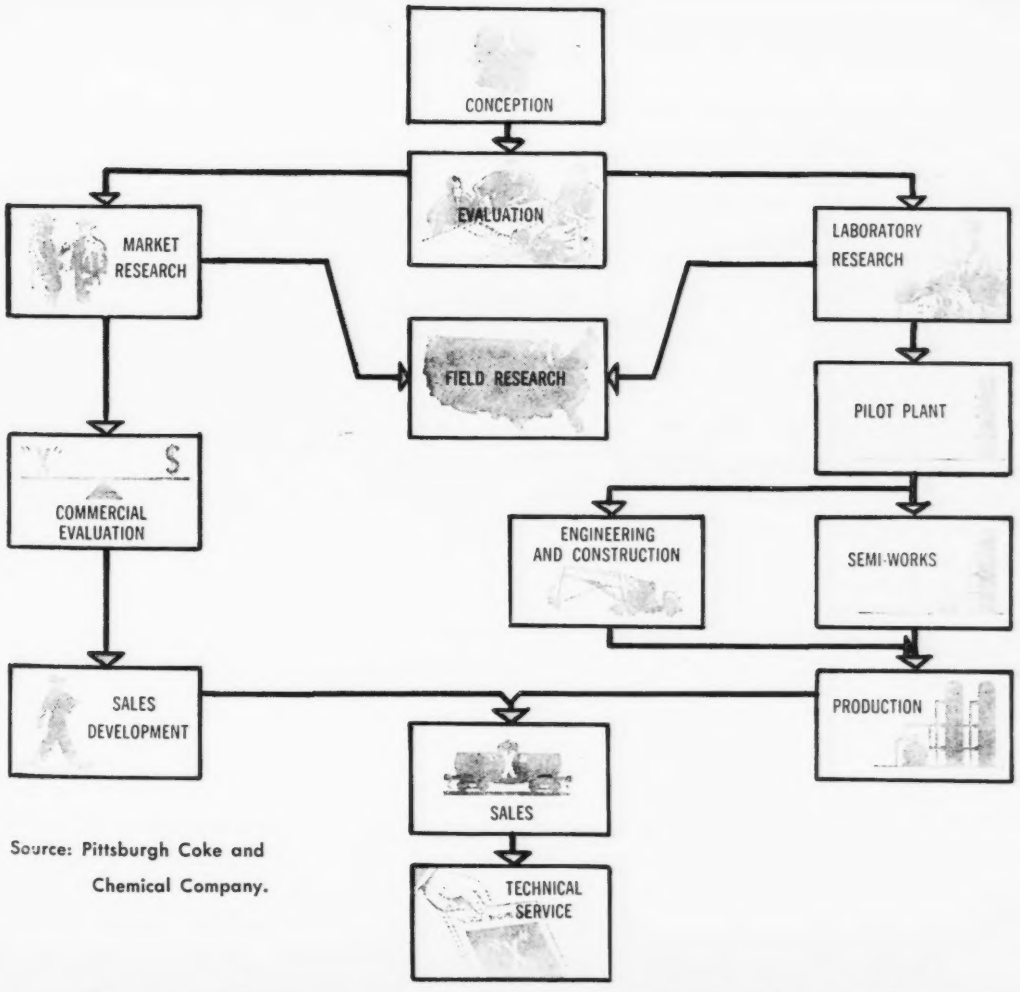
TEST SALES OF TREATED FARM POSTS, p. 18

Forest Products Journal





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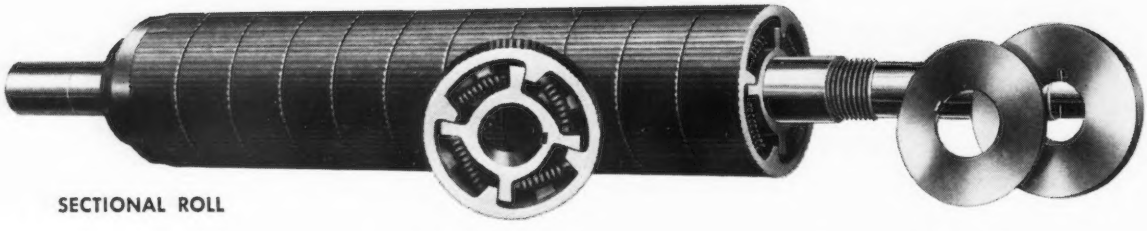

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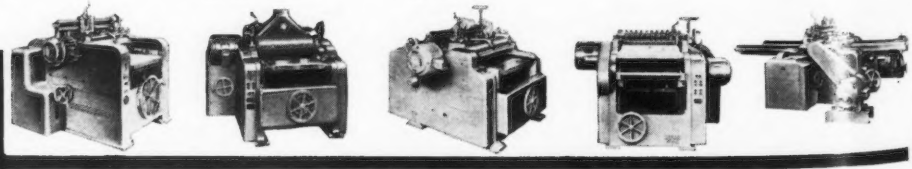

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THE FOREST PRODUCTS JOURNAL is published monthly by the Forest Products Research Society, P. O. Box 2010, University Station, Madison 5, Wisconsin. Entered as Second-Class Matter, April 1952 at the Post Office, at Madison, Wisconsin.

Annual subscription rate, $15.00; single copies $1.00, except October Yearbook Number, $4.00. Annual subscription rate is $11.25 with voting, associate, and supporting memberships in the Society. Remittances should be made payable to the Forest Products Research Society.

Correspondence on editorial matters should be addressed to the Editor, at the Executive Office. The Society is not responsible for views expressed in publications.

FOREST PRODUCTS JOURNAL

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IMPORTANT FPRS DATES

Oct. 21–22: Mid-South Section Meeting, Crossett, Ark.

Oct. 25: Northern California Section Meeting, Ukiah, Calif.

Oct. 31–Nov. 1: Northeast Section Meeting, New York City

Oct. 31-Nov. 1: Carolinas–Chesapeake Section Meeting, Roanoke, Va.

Nov. 8: Rocky Mountain Section Meeting, Denver, Colo.

Nov. 14–15: Mid-West Section Meeting, Milwaukee, Wis.

Dec. 5–6: Florida–Georgia–Alabama Section Meeting, Daytona Beach, Fla.

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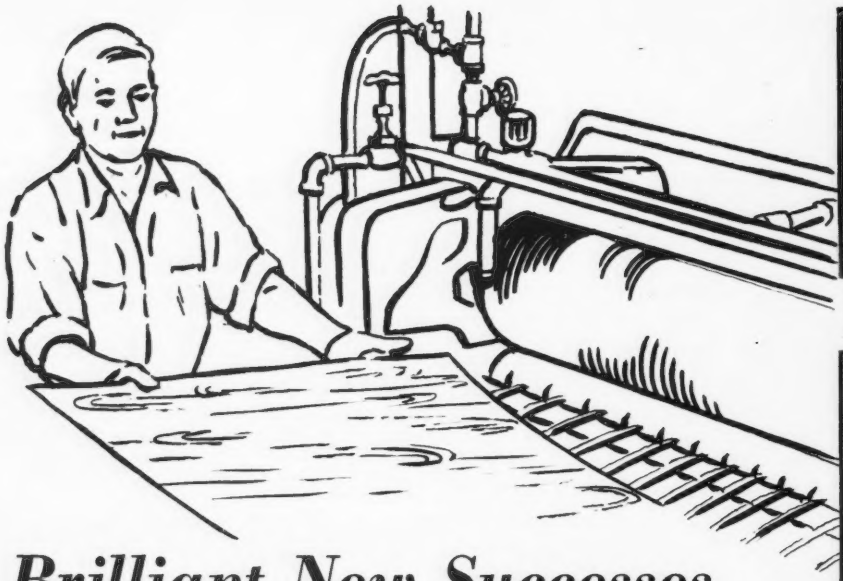

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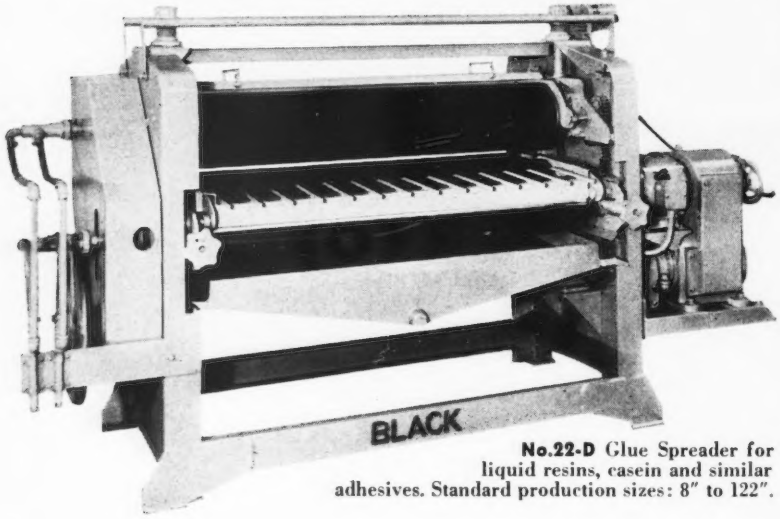

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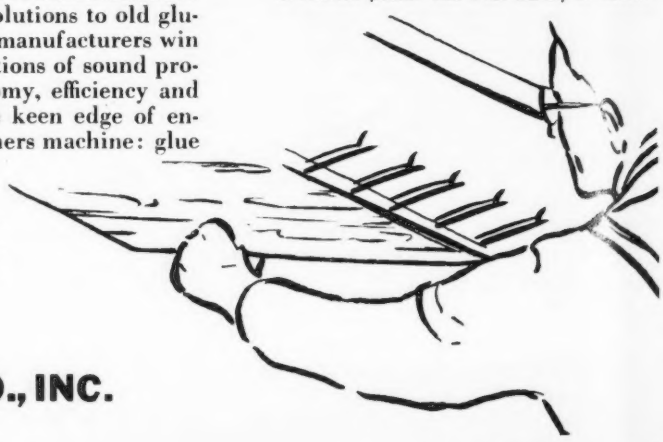

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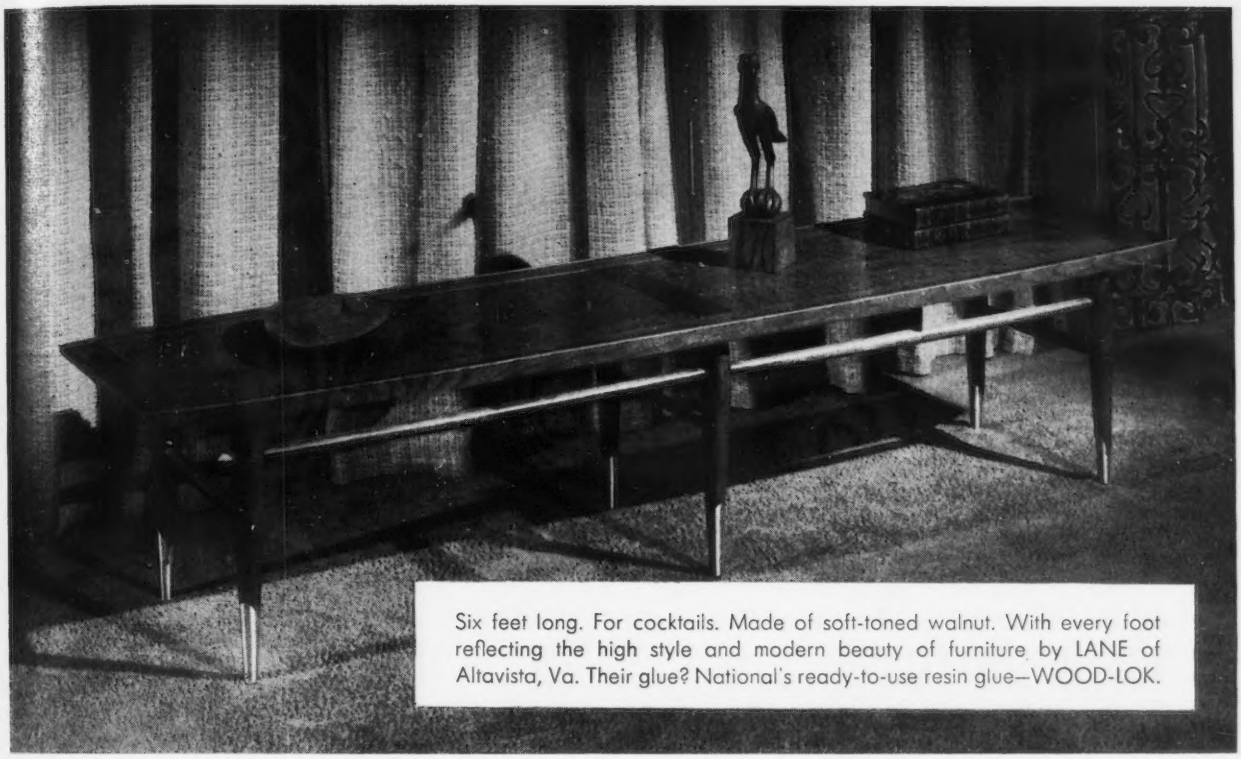

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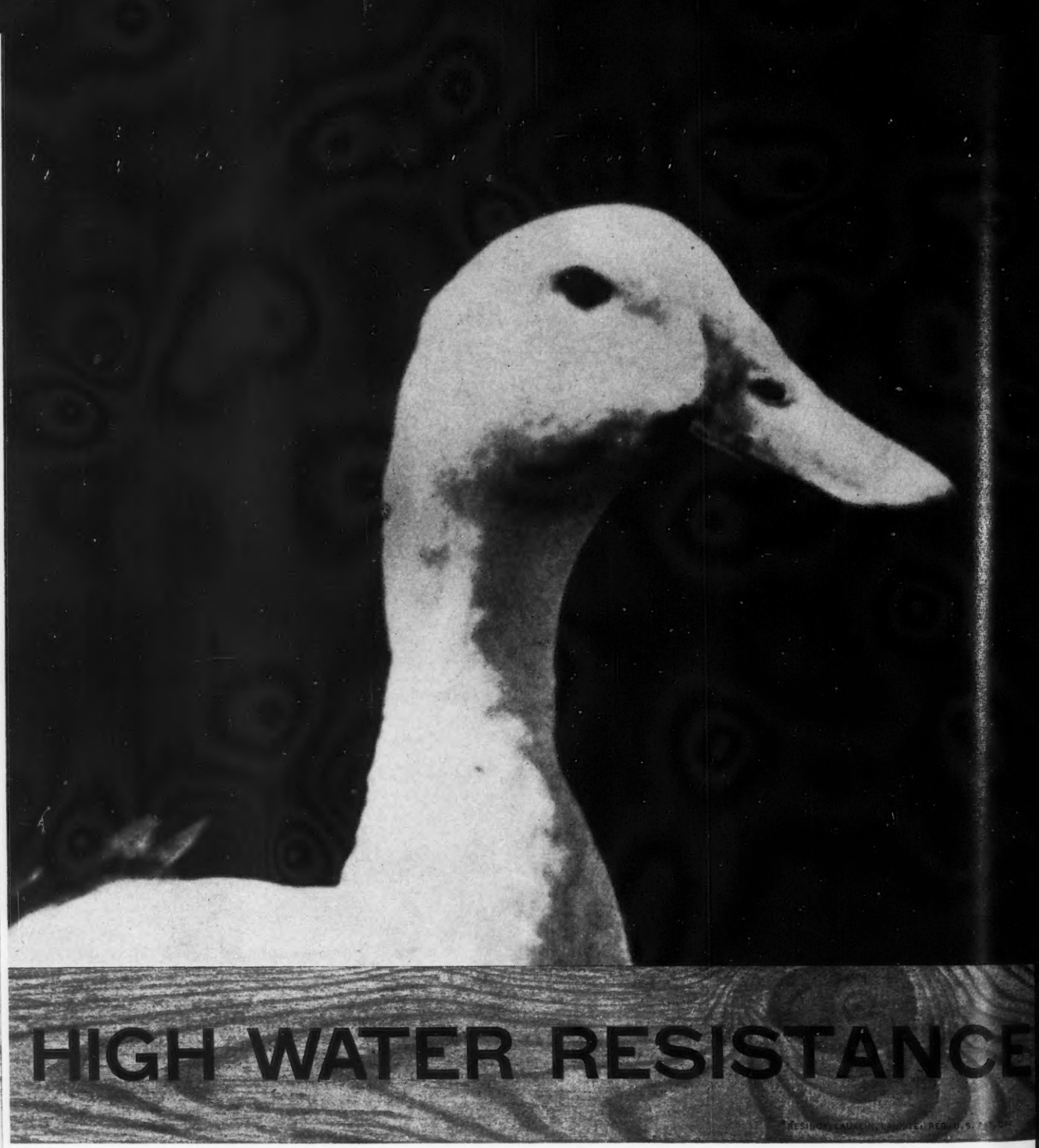

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FPRS NEWS-DIGEST

Volume VII SEPTEMBER, 1957 Number 9

Papers Needed for 1958 National Meeting

Potential Authors Urged to Contribute Papers

Plans are well underway toward what is expected to be the largest FPRS National Meeting in the Society's history, according to Robert L. Hiller, General Chairman of the 12th National Meeting, June 22–27, 1958, Madison, Wis. Technical sessions are planned to cover the following subjects:

1) Composition Board, including hardboards and particle board
2) Chemical Utilization of Wood
3) Drying and Seasoning
4) Glues and Gluing
5) Finishes and Finishing of Wood
6) Industry–Education Coordination
7) Logging Technology
8) Lumber Manufacturing
9) Quality Control
10) Veneer and Plywood
11) Wood Preservation

An all-inclusive "General Session", to provide for nationally prominent speakers in the fields of research, government and industry is also planned.

Member Participation Needed

Technical programs held at the National Meetings are the direct product of the interest and work of the Society's 14 major subject divisions, and are dependent upon contributions of technical and non-technical papers from FPRS' three principal sources of membership: industry, education, and government. Suggestions and contributions regarding the technical program for the 12th National Meeting are urged from the general membership.

Communications should be directed to Mr. W. Jeter Eason, Nickey Bros., Inc., 2700 Summer Avenue, Memphis 12, Tenn.; to the National Office, or to chairmen of the divisions. Potential authors should state briefly the intended scope of their paper and other aspects of their project which they feel will make their paper a valuable contribution for the National Meeting Program.

Ukiah, Calif., Site of Northern California Meeting

The fall meeting of the Northern California Section, October 25, will be held at Ukiah, California, according to Thomas Shelton, chairman of the section.

A tour of the Masonite Corporation at Ukiah will open the meeting, and will be followed by a social hour at the Palace Hotel, and a dinner at 7 p.m.

Mr. Dale Turner, Superintendent of Research at the Masonite plant will give an after dinner talk entitled "Review of Flow and Processes at the Plant". "Procedures and Problems in the Handling of Raw Material for Hardboard" is the title of the second paper that will be given that evening.

Five Papers Planned for Rocky Mountain Meeting

Five papers will be presented at the fall meeting of the Rocky Mountain Section Meeting, November 8, at Denver, Colo., according to W. R. Fritze, program chairman. Headquarters for the meeting will be the Cosmopolitan Hotel.

With Waste Wood Utilization the theme of the meeting, Floyd B. Joy, Ace Box Co., Denver, will speak on "Problems of Waste Wood Utilization in a Rocky Mountain Operation". Four other speakers scheduled are: H. E. Troxell, Colorado State University; U. Ray Armstrong, Hallack and Howard Lumber Co.; Robert Bader, Raybond Electronics, Inc.; and G. G. Marra, Washington State Institute of Technology.

Tours to Be Featured at Mid-South Meeting

"Forests and Their Products" is the theme of the Mid-South Section Meeting, October 21–22, at the Rose Inn, Crossett, Ark., according to W. L. Lear, secretary-treasurer of the section.

Highlighting the theme will be a series of tours of the Crossett Experimental Forest, a branch of the Southern Forest Experiment Station at New Orleans, and of the Crossett Co. plants, including the sawmill division, chemical plant, and paper mills. J. H. Rowland, Reynolds Metals Co., will speak at the official dinner, October 21, and the official luncheon speaker, October 22, will be T. L. Latané Temple, III, Southern Pine Lumber Co., Diboll, Texas.

A panel discussion on "How Good A Tree Should We Grow" will be moderated by R. R. Reynolds, Crossett Experimental Forest. Panel members include: M. A. West, Texas Creosoting Co., Orange, Texas; George Stanley, Kirby Lumber Corp., Houston, Texas; B. E. Mikulka, Love Wood Products, Diboll, Texas; and Russell Stadelman, Nickey Bros. Inc., Memphis, Tenn.

Registration fee is $6.00 for members and non-members and hotel reservations and preregistration should be made through W. L. Lear, Crossett Lumber Co., Crossett, Ark.

Elections Scheduled for Carolinas-Chesapeake Meeting

The fall meeting of the Carolinas–Chesapeake Section, October 31–November 1, will be held at the Hotel Roanoke, Roanoke, Va., according to Michael A. Taras, secretary-treasurer of the section.

Featured at the technical program will be Alfred J. Stamm, Forest Products Laboratory, who will speak on Methods of Improving Dimensional Stability in Furniture Manufacturing. Election of new officers will be held and two resolutions involving changes in by-laws will be voted upon.

President's Column

ST. PAUL, MINN., Aug. 20—In this, my first communication to our members at large, let me express my deep appreciation to my many good friends throughout the educational, governmental and industrial ranks of our industry for your confidence in me. All of you have helped build and develop the Forest Products Research Society to its present position of importance in the forest products industries. It has taken a great deal of effort on the part of many individuals and continued financial support and contributions of all interested individuals and companies to bring us to our 1957 stature. It will require your continued support and interest to further develop the Society to the type of organization most of us feel it should be.

F. H. KAUFERT

I am convinced, and I am certain that this conviction is shared by everyone associated with the forest products industries, that our Society has helped stimulate and develop research. Research is today the backbone and sinew of all industries and of our entire economy. It is all-important and determining to the forest products industry, an industry that produced products valued at more than $15 billion in 1956. In terms of total products value as well as value added by manufacture ($8 billion), it is one of our largest basic industries.

Research—Our No. 1 Job

What our Society has done to stimulate research in the past is important, but what it does to help continue this growth in the future is even more critical. Without continued emphasis on and growth of forest products research, our industry cannot compete, grow, and develop in competition with competing industries that invest ever-increasing sums in research. The stimulation of forest products research at all levels and in all agencies must continue to be our number one objective.

Goal—5,000 Members

Our organization has made a sound and steady growth since that date in January 1947 when 14 persons gathered to formally establish the "Forest Products Research Society". Yet as pleasing as this growth has been, we must necessarily compare it with the total "market potential" of the industry we serve. This means that today, some 10 years later, we have gained but 4% of the potential in an industry representing more than 100,000 mills, firms and other organizations. Therefore, our second objective should be to achieve within the space of the next 10 months a membership increase which will be greater than the nominal 10% improvement which we have noted annually in recent years. I believe we should strive not for 4,000 members in the near future, but 5,000 members. In increased membership there is increased strength and added finances with which to publish our Forest Products Journal and render services to members and the industry we serve.

Proposed Home Office Building

A third major objective is to see the proposed new executive office building well under way by the time of our National Meeting in Madison, Wisconsin, next June 22–27. Your Executive Board has agreed that there will be no deficit financing of this building. Our goal is $60,000 in cash and material contributions and pledges. Since the first of the year we have achieved $25,000. In addition, we have assets ear-marked for this building in the amount of $10,000. I urge each member to suggest to his management that his organization make a modest contribution to this building. Also, that individual members and Sections contribute whatever amounts they deem suitable. I am confident that we will continue to build the necessary fund and that, by the time of our September Board meeting in Madison, our national officers will be ready to proceed with the letting of the building contracts. A special salute from all Society members is due Ray Berry, Southwest Region Executive Board member and Chairman of the Executive Office Building Fund Committee for the tremendous amount of work done and progress made to date. Let's all help him bring this important job to a successful conclusion.

Your full support will be needed to achieve these objectives. Your Officers and Executive Board will do their utmost to lead your Society toward fulfillment of these objectives in the critical and important year ahead. Please feel free to write me, President-Elect Eason, Vice-President Harrar or Regional Board members if there is anything we can do to help build membership and programs and help further the Building Fund towards its goal.

FRANK H. KAUFERT, *President*

Technical Sessions Planned for Northeast Meeting

Imported Woods, Modifying Wood for Use, and the Handling of Wood Products, will be the three main subjects of the Northeast Section fall meeting, October 31–November 1, at the Prince George Hotel, New York City, according to Dr. Eric A. Anderson, section chairman.

J. J. Beach, Silent Hoist & Crane Co., will speak on "Fork Lift Truck Handling of Wood Products" at the session on handling wood products. "Palletizing of Wood Products" will be the topic of William H. Sardo, Jr., National Wooden Pallet Manufacturers Assoc. and P. Williams, Jr., Moore Dry Kiln Co., will speak on "Unloading Lumber from Box Cars".

During the imported woods session, Jean Kohn, Balso Ecuador Lumber Corp. will describe "Low-Density Imported Woods" and Joseph Stearns, Insular Lumber Sales Corp., will present information on "High Density Imported Woods." Robert N. Hawes of the law firm of Hawes, Gosnell and Dougherty will explain "Market Problems Raised by Imported Plywood."

The Modifying Wood session will include a discussion of "Modified Ligno–Cellulose Product" by J. Allan Hauter, Allan Products Co. "High Temperature Drying of Wood" will be treated by a member of the Canadian Forest Products Laboratory, and Magnus Selbo, U. S. Forest Products Laboratory, will present findings on "Setting Rates of Resorcinol and Phenol Resin Glues". William Nearn, Pennsylvania State University, will give a running commentary on an animated film on the shrinkage of wood and the movement of water molecules in wood.

"Tomorrow is Here Today", which is concerned with materials handling, will be the topic of the principal luncheon speaker, R. C. Sollenberger, executive vice president, Conveyor Equipment Manufacturers' Assoc. Three round-table discussions with audience participation will also be held.

Registration for the meeting may be made by writing Dr. B. Jayne, School of Forestry, Yale University, New Haven, Conn.

Send for Your FPRS Lapel Pin

Buy and wear an FPRS lapel pin. It will identify you as an active supporter of wood industry research and progress. The attractive green and gold pins are available for 75 cents. For an additional 25 cents, you can receive 8 x 10 frameable membership certificate. Send your order to Executive Secretary, Box 2010, Univ. Station, Madison 5, Wis.

Over 100 Attend Upper Mississippi Valley Meeting

BERT E GRANUM makes a point with M & O men at the official luncheon.

MORE THAN 100 turned out for the panel, "What's New in Fiberboard Products".

EVENING BANQUET was attended by 125 men and women.

UMV SECTION officers meet with Pres. Kaufert. L. to r., Walter Wallin, Howard Olson, Henry C. Crandall, Chrm., Wayne Meek, Exec. Sec. F. Rovsek, and Pres. Kaufert.

INFORMAL CHAT between Wayne C. Lewis, fiberboard expert, Pres. Kaufert, and W. H. Schlafge, M & O International Falls general manager.

E. L. LAMB, principal banquet speaker.

M & O utilizes wood for chemicals storage tower.

GRINDING ROOM visited during tour of the M & O plant.

FINISHED INSULITE panels leave M & O production line.

Upper Mississippi Valley Holds Successful Meeting

More than 100 members and guests attended the recent Upper Mississippi Valley Section Meeting, August 15–16, International Falls, Minn., the theme of which was "Fiberboard Products". Program chairman was Wayne Meek, Minnesota and Ontario Paper Co.

Highlighting the opening luncheon and business meeting, with section chairman Henry C. Crandall presiding, was the section pledge of an additional $300 to the building fund. The tour of the M & O Insulite division that followed included the world's largest standing pile of pulpwood (some 300 days operating supply) and the step-by-step production of insulation-board products.

"The great increase in demand for fiber", predicted Mr. E. L. Lamb, M & O Paper Co., at the evening banquet, "will be satisfied largely from extended use of hardwoods, especially in the southern part of the country, the increased recovery of mill wastes, higher pulp yields, and, over a longer period, increased growth of timber on a unit of land as a result of better management of forest stands."

"It seems pretty certain", he said, "that the demand for pulpwood for fiber production will approximately double in the next 20 years, and that the paper and board industry will have to face up to some fairly substantial changes in sources of raw material and in the processing of it to accommodate this increasing demand."

FPRS President Frank H. Kaufert addressed introductory remarks at the banquet. A panel discussion on "What's New in Fiberboard Products" was moderated Friday morning by Wayne C. Lewis, U. S. Forest Products Laboratory.

Panel participants were: F. R. Eggers, NuPly Corp., Benmidji, Minn.; A. S. Bull, Minnesota and Ontario Paper Co., Minneapolis, Minn.; G. E. Chamberlin, Minnesota and Ontario Paper Co., International Falls, Minn.; George Fewson, Superior Wood Products, Duluth, Minn.; Clare E. Swanson, Wood Conversion Co., St. Paul, Minn.; Ray Chase, Masonite Corp., Chicago, Ill.; and Daniel Koch, Weyerhaeuser Sales Co., St. Paul, Minn.

Side trips through the M & O research department, and experimental forest plots concluded the two day meeting.

BUSINESS NOTES

Furniture

The furniture industry still has an opportunity to make 1957 the best year in the history of the industry, according to John M. Snow, executive vice president of the National Association of Furniture Manufacturers.

Shipments by furniture manufacturers have been closing the gap that exists between current volume and the record breaking year of 1956, the July monthly business report of the NAFM shows. A recent survey by the association showed that the majority of manufacturers believe that in total 1957 would be a good year.

At the end of May, industry shipments were 6 per cent off the 1956 pace. In June the difference was 5 per cent and July shipments, which were 3 per cent in excess of July last year, made total shipments for the first seven months only 4 per cent below last year.

After a couple of months in which shipments were below the 1956 pace, July shipments of casegoods were only 1 per cent below last year. Total shipments for the seven month period were at 3 per cent below 1956 as of the July report.

Pacific Northwest Pulpwood

Pulp and paper mills of the Pacific Northwest Douglas-fir region are getting 42 per cent of their raw material from slabs, edgings and other leftovers, according to W. D. Hagerstein, executive vice president of the Industrial Forestry Assn., Portland, Ore.

Mr. Hagerstein said the log scale equivalent of chips being used by pulp and paper mills in the fir region is 1.25 billion bd. ft. annually. He reported that there is still enough leftover wood at primary wood-using plants in the region to produce upwards of one and a half million tons of wood pulp per year.

Southern Pulpwood Production

Southern pulpwood production broke all records for the year 1956, according to the Southern Forest Experiment Station, New Orleans. The harvest of 20.3 million cords was 11 per cent more than in 1955, and accounted for 57 per cent of the pulpwood used in the nation during the year.

In 10 years, daily pulping capacity in the South has risen from 16,000 tons to 38,000. Chipped residues from wood-using industries totaled 659,100 cords, nearly double their volume in 1955. Southern pine comprised 86 per cent of the 1956 total, hardwoods 14 per cent. Sixty-eight southern mills were operating at the end of 1956. Nine more are under construction or are being planned.

Charcoal Production

Charcoal production was 265,000 tons in 1956, according to a study completed by the U. S. Forest Service. About 50 per cent of the charcoal produced is being used for cooking, picnics and camping, and in restaurants and dining cars.

Chemical and metal industries used from 35 to 40 per cent, and the rest was utilized for curing tobacco, poultry feed, and water purification. The East produces 98 per cent of the total, while California is the only western state with a well-established charcoal industry. There are 240 known charcoal producers. In 1956, 74 per cent of the production was from roundwood, 26 per cent from slabs and edgings.

Foresters Plan Annual Meeting

"Forest Land Use in Transition" will be the theme of the 57th annual meeting of the Society of American Foresters, November 10–13, at the Hotel Syracuse, Syracuse, N. Y.

Technical fields discussed at the meeting will be: forest management, silviculture, forest products, private forestry, range management, public relations, forestry education, forest economics and policy, watershed management, wildlife management, and forest recreation.

Keynote speakers are: George A. Garratt, Yale University School of Forestry, New Haven, Conn.; Ralph W. Marquis, Northeastern Forest Experiment Station, Upper Darby, Pa.; and Edward W. Littlefield, N. Y. State Conservation Dept., Albany. Dwight B. Demeritt, Dead River Co., Bangor, Me. will introduce the speakers at the opening session.

Weyerhauser Technical Center Reorganized

Recent reorganization of the Weyerhaeuser Timber Co. Technical Center, Longview, Wash., brought into being three new departments, all of which are still located at the Technical Center site.

The new departments are Central Research, managed by A. S. Gregory; Central Development, with E. M. Williston as manager; and Technical Center Services department with A. S. Mark as manager.

Research directed toward new products and processes for future commercialization by the company is the primary concern of the central research department. The central development department is involved mainly with product and process improvements, pilot plants, and market studies on all new products except pulp and paperboard.

Technical Center Services department supplies library, accounting, purchasing and similar service functions to the technical groups at the center.

New TECO College Outline Available

A new college outline in timber design and construction has been prepared by Timber Engineering Co., engineering and research affiliate of the National Lumber Manufacturers Association, according to Ralph H. Gloss, senior structural engineer and corporate secretary.

Covered in the outline are: physical, chemical and structural properties of wood, design considerations, post and beam construction, types of roof trusses and fastening devices, exterior structural design and construction methods, as well as pertinent data.

The outline is designed to serve as a guide for a separate college course, or as a supplement for other courses in timber design. It follows closely the "Timber Design and Construction Handbook" prepared by Timber Engineering Co. Copies are available free of charge from Timber Engineering Co., 1319 18th Street, N. W., Washington 6, D. C.

Wood Promotion Needed Say Hardwood Mfr's.

"Wood has never been sold—but the time has arrived when this is a must," said Ernest Clevenger, vice president, Corley Manufacturing Co., at the summer meeting of the Appalachian Hardwood Manufacturers, Inc., Hot Springs, Va.

Mr. Clevenger pointed out that competition exists now not just between exponents of various types of wood, but between the lumber industry and substitute products which are being promoted as replacements for wood. He called for "salesmanship of the highest degree".

A specific program for promotion of wood use was discussed by Carroll Cass, U. S. Plywood Corp., Charlotte, N. C. He described the "Better Offices In Friendly Wood" program launched recently in Minneapolis and supported by 12 regional associations co-operating in a nation-wide effort to extend the use of wood in offices.

Computer–Microscope

A new electronic computer–microscope, automatically computing the age and annual growth of trees has been developed by Swedish scientists. The number of concentric rings and the width between them are counted when a core of wood from the tree is fed into the machine.

Radioactive Carbon 14 Used To Study Cellulose Characteristics

Radioactive carbon 14 has been injected into the trunk of a small pine tree recently by a scientist of Rayonier, Inc., near Whippany, N. J. The injection tagged this year's growth ring in the tree for use in later pioneering research.

Acting as tracers, the radioactive carbon remains after the tree goes through various mechanical and chemical production steps. It is expected to help researchers follow cellulose characteristics and behavior through to any end product capable of being reproduced in the laboratory.

New Equipment Used To Find Flaws In Wood

Ultrasonic equipment is being used to find flaws in wood, said M. J. Woodman and J. S. Waid, Merlewood Research Station, Lancashire, England, in a report published recently by Nature Magazine. Ultrasonic devices send high frequency waves through the wood and record variations in the waves caused by bad spots.

The researchers reported that ultrasonic waves could be transmitted through four feet of sound, seasoned beech, but that no transmission occurred at all through a two-inch piece of red pine infected with dry rot.

Combined WMMA and SFMA Meeting

"What The Woodworking Industry May Expect From The Woodworking Machinery Industry" was the subject of a panel discussion presented by the Woodworking Machinery Manufacturers' Assoc. to the Southern Furniture Manufacturers' Assoc., September 6, at a meeting of the SFMA Production and Cost Division at Blowing Rock, N. C.

The WMMA panel members discussed advantages and reduced costs made possible by modern machines. The panel discussion was led by H. H. Joseph, Jr., vice president and treasurer of Handy Manufacturing Co., and Robert M. Miller, vice president and sales manager of Onsrud Machine Works, Inc., both of Chicago, Ill.

Pulpwood Potential Survey Launched for State of Washington

A survey of the state of Washington pulpwood potential has been initiated by the Institute of Forest Products, Wash. The importance of the survey is illustrated by the fact that paper pulp produced during the past year in Washington State was valued at almost four million dollars, one-third more than the value of lumber produced in Washington during the same period.

Work of U. S. Forest Products Lab. Shown in New Motion Picture

"A Piece of Wood", the first official motion picture in 20 years about the work of the U. S. Forest Products Laboratory, Madison, Wis., has been released, Director J. A. Hall announced.

The full-color, 16-millimeter film was produced by the U. S. Department of Agriculture for the Forest Service. Highlights of the film are changes brought about in the pulp and paper industry by new processes developed at the Laboratory, and the rapid expansion of the laminating industry as a result of research in the gluing and laminating of wood.

Scenes depicting investigations on the preservative treatment of wood, the use of treated paper as a smooth, clear surface for knotty boards, paints and painting, and processes for extracting chemicals from low-quality woods are shown.

A dramatic example of industrial application of laboratory research, is a scene showing the testing of a laminated wooden arch in a four-story-high machine, with the action moving to the building of a sports arena with mammoth arches similarly glued from ordinary lumber. The 13½ minute film, with sound track, is available on free loan to groups. Prints can be obtained by writing any regional office of the United States Forest Service.

New York College Surveys State's Wood-Using Industries

A survey covering the species and amounts of wood used in manufacturing wood products in New York State has been completed by State University of New York College of Forestry, Syracuse. Results of the study have been published in a bulletin, "Wood-Using Industries of New York," by R. C. Deckert and R. J. Hoyle.

The report, which includes all wood-using firms except pulp and paper and sawmills, shows that the state now uses 658 million board feet annually in producing 53 classes of products. Douglas-fir is the leading wood in amount used, with 82 per cent used by three of the large industry classifications, boats and ships, general millwork, and prefabricated structures.

Copies of the report are available at $1.50 each from the Dept. of Forest Extension, College of Forestry, Syracuse 10, N. Y.

Oregon State College Receives Research Grant

The reduction of cinder and smoke nuisance from wood waste burners used by sawmills and plywood mills will be studied this year by Oregon State College with a $12,000 air pollution research grant from the U. S. public health service.

A scene from the film "A Piece of Wood" about the U. S. Forest Products Laboratory.

The design and operation of the burners, used mainly by small and medium sized mills that do not dispose of wood wastes by chipping and selling chips for wood products manufacturing, is believed crucial in the reduction of air polution, according to Milosh Popovich, assistant dean of engineering and project leader.

Cooperating in the study are the Oregon state air pollution authority and the Oregon Forest Products Laboratory. A report will be issued when the study is completed, recommending procedures which will reduce pollution.

Three Schools Expand Forestry Program

Clemson College, Clemson, S. C. and Humboldt State College, Eureka, Calif., have recently expanded two-year-forestry programs to four years, leading to a bachelors degree. Forest management will be taught at Humboldt State College. Clemson will feature a forestry curriculum.

A graduate program in continuous forest control has also been announced for Purdue University by E. R. Martell, head, department of forestry.

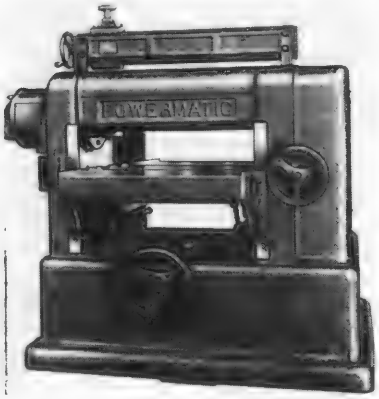
NEW PRODUCTS—LITERATURE

New Wood Saw Catalog

"Huther Bros. Wood Saws" is the title of a new catalog WS-300 that illustrates and describes saws used in wood working. Shown are all types of circular saws, groovers, cutters, trimmers, knives and slitters. Band saws and special mounting devices are also included. The catalog is available from Huther Bros. Saw Mfg. Co. Inc., 1290 University Ave., Rochester 7, N. Y.

New Planer

A single surface planer with an exclusive quick-set table roll adjustment has been added to line of woodworking machinery produced by Powermatic Machine Co., McMinnville, Tenn. The feature reportedly allows an operator to make change-over from rough stock to semi-finished lumber within seconds. A small lever on the front of the unit can adjust table rolls from 0 to .040 inches.



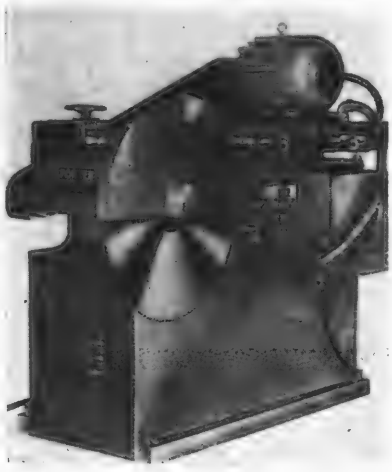
Another feature is a variable feed unit controlled by a calibrated handwheel to the right of the bed, which permits a complete range of feeds from 20 to 100 feet per minute. Two Reeves variable speed pulleys, driven by a 1½ hp motor make feed stalling virtually impossible, the manufacturer reports.

Complete specifications and details on the model 225 24-inch planers are outlined in an illustrated folder available from the manufacturer.

Cut-Off Saw

A heavy-duty cut-off saw is being produced by C. O. Porter Machinery Co., Grand Rapids, Mich. Model 45 Hydracut features a hydraulically operated carriage and is available in two maximum stroke sizes of 24 and 36 inches with variable adjustments up to these maximums. Carriage speeds, both cutting and return feed, are variable from zero to 55 feet per minute.

Both the 24 and 36 inch sizes are available in two motor horsepowers, single speed up to 15 hp or a four speed 7½ hp.



Vapor-Sealed Roof Slab

A vapor-sealed insulating roof slab developed and marketed by the Celotex Corp. provides structural roof deck, insulation, and a finished ceiling. A built-in rubber gasket set in permanently along the long tongue edge of the slab and continued across the short edge provides the vapor seal.

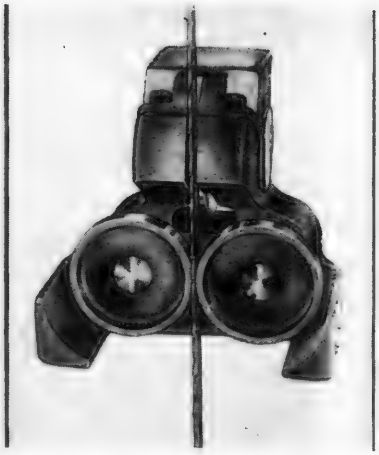
Units are made of insulation board in 2 x 8 foot size with a choice of 2 or 3 inch laminated thicknesses. Celotex reports roof slabs without vapor barriers are available for use in temperate zones, and that both types meet FHA requirements. Ceiling surface, including the bevels of the long edges, is factory finished in white.

New Catalyst Developed

To combat the problem of formaldehyde fumes in hot press gluing with urea formaldehyde resins, Perkins Glues has developed a special catalyst, NF–16. Used in veneering or in waste-board manufacture, it is reported that it virtually eliminates free formaldehyde. NF–16 can be used in board produced either by extrusion or by the batch method.

Bandsaw Guide

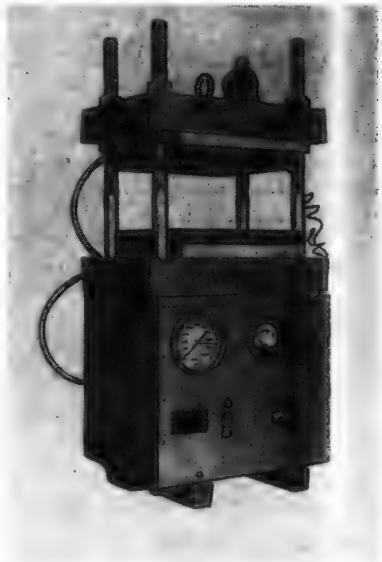
A new bandsaw guide with the edge of the blade riding on the outside perimeter of thrust wheel and with thrust wheel and support rollers all operating on the inner raceway of the bearing is being produced by Carter Products Co. Inc. of Grand Rapids, Michigan.



The "Guidall 400" handles blade speeds up to 15,000 fpm, and is reported to work equally well on light and heavy loads. It will handle thrust loads to 175 lbs. at maximum speeds and to 500 lbs. at lower speeds, and accommodates saw blades from 1/16 inch to 2½ inch.

Hydraulic Laboratory Press

A 4-post, 30-ton hydraulic laboratory press designed to do laminating, parquetting, small run and experimental veneer work, testing adhesives and other high-pressure jobs around woodworking plants has been added to the line of the Wabash Metal Products Co., Wabash, Ind.



The hydraulic unit can exert 60,000 lbs. pressure and has a maximum opening between platens of 10 inches. Its stroke is 6 inches. The heating platens that are furnished may be removed for work that does not involve heat. A manually operated machine, it is also available motorized.

Treatment for Ground-Line Rot

K-BAN, a bandage-type treatment for preventing ground-line rot and insect damage to standing poles, is now being marketed by Chapman Chemical Co., Memphis, Tenn.

The bandage consists of a preservative grease enclosed in an envelope of thermo-plastic coated paper. To apply, the bandage is opened to 24-inch width and wrapped around the pole with about 2 inches protruding above the ground line, with staples holding it in place.

The grease used contains 10 per cent of pentachlorophenol, and sodium fluoride is also included to speed the protective action on extremely damp poles.

Carbide Planer Knives

Advantages of carbide knives on machine planers in woodworking plants are described in Bulletin WK–100, issued by Kennametal Inc., Latrobe, Pa. Results obtained with Kennametal knives in various planing operations in several woodworking plants are disclosed. Methods of adapting present machine planers for use of hard carbide planing knives are explained.

New Automatic Barker

Claimed to be the largest, fully automatic barker ever built in the United States is the 43-inch cambio barker by Soderhamn. This new size handles 12 foot logs and longer, from 7 to 43 inches in diameter. Operating at speeds up to 90 fpm, it requires no operator.

Tool-tensioning is by rubber bands and hydraulic controls, and may be changed by push-button while in operation. Feed speeds also are varied by push-button controls. Moving parts are sealed against dirt and dust, and are automatically lubricated.

Makers of the cambio barker claim that the bark cutter entirely eliminates the problem of stringy bark, and performs well within any bark specifications, even when handling mixed hardwoods.

Hand Rivet Spinner

A new hand rivet spinner for use in assembling saw chain links is being manufactured by the Oregon Saw Chain Division of Omark Industries, Inc., Portland, Ore. It gives equal pressure and equal holding strength all around the rivet shank. Made of cast iron, the spinner comes with two threaded take-up handles and two interchangeable spinner mandrels that fit all chain sizes except 0.404 pitch. Mounting holes are provided in the base.

Carbide Tipped Tools Booklet

A new 24-page booklet, "Carbide Tipped Saws and Tools," is available from the Saw Division of R. Hoe & Co., Inc. Typical materials that can be cut with carbide cutting edges are listed with brief tips on how to obtain optimum cutting results. Data pages are noted where detailed cutting data may be found for different materials and cutting operations. Write, R. Hoe & Co., Inc., 910 E. 138th St., N. Y. 54, N. Y.

Pushbutton Spotnailer

A new model pushbutton spotnailer that will drive 1½-inch fasteners without recoil or shock is now being produced. Because it is completely pneumatic, no piston-return springs are required and it reportedly permits fastening of longer fasteners through harder materials. The spotnailer requires no more than 100 p.s.i. pressure.

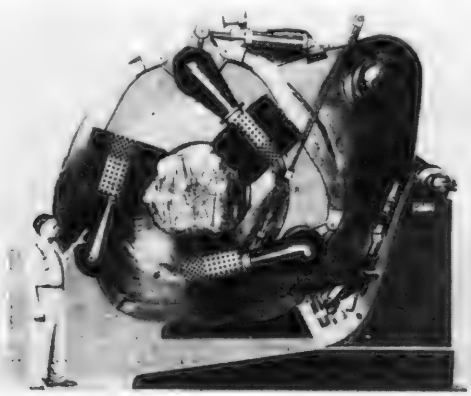
NAMES IN THE NEWS

Richard L. Campbell has been appointed Project Engineer for three Johns–Mansville insulation board plants located at Jarratt, Va., Natchez, Miss., and North Bay, Ont., as well as the plant under construction in Klamath Falls, Ore.

Organic chemist **Harvey Aft** has joined the technical staff of the Oregon Forest Products Laboratory, Corvallis, and will work as a research associate in wood chemistry. **William W. Gleaves,** University of Idaho and Duke University, has been appointed assistant in timber mechanics at the Laboratory and **Charles J. Kozlik,** graduate of Doane College and Duke University, will work in wood seasoning.

C. H. DRIVER

Dr. Charles H. Driver has been appointed director of forest research at the International Paper Co.'s new Southlands Experiment Forest, Bainbridge, Georgia, it was announced recently by Erling Riis, vice president and general manager of the Southern Kraft Division.



NEW PUBLICATIONS

Chemical Debarking of Southern Trees. Warren S. Thompson and Keith C. Birdsall. Technical Bulletin 42. Summarizes the procedures and results of a study testing chemical debarking. Available from Mississippi State College, Agricultural Experiment Station, State College, Miss.

Production of Wallboard From Wood Waste. F. Bender and F. W. King. Bulletin No. 120. Contains information on the wallboard research work of the Forest Products Laboratories of Canada, with data on types of boards and their uses. Available from the Forest Products Laboratories of Canada, Dept. of Northern Affairs and National Resources, Ottawa, Ontario.

Red Heart Stain of Lodgepole Pine Logs in the Northern Interior of British Columbia. H. W. Eades and J. W. Roff. V-1023. A description of a survey of the causes of red stain in lodgepole pine. Available from the Forest Products Laboratories of Canada, Dept. of Northern Affairs and National Resources, Vancouver, B. C.

Grading Hardwood Logs For Factory Lumber. W. W. Calvert. A study of Canadian hardwood tree species as a basis for an orderly and accurate appraisal of factors affecting quality in the primary forest products. Available from the Forest Products Laboratories of Canada, Dept. of Northern Affairs and National Resources. Ottawa, Ontario. Reprint from Timber of Canada.

The Yield of Sawmill Residue Pine Pulp Chips by Sawlog Size. Paul R. Kramer. Circular No. 56. Shows the relationship between log diameter and chip yield. Available for a small charge (out-of-Texas-requests) from Director, Texas Forest Service, College Station, Texas.

Charcoal Production. Montgomery R. Childs. This report points out that charcoal can be produced from all species of wood and from almost any form and size of forest and mill waste. Available for a small charge (for out-of-Texas-requests) from Director, Texas Forest Service, College Station, Texas.

The following publications are available without charge from the U. S. Forest Products Laboratory, Madison, Wis.

List of Publications January 1 to June 30, 1957.

Suitability of Short Lumber for Pallets. Presents the results of tests made to determine whether the butt-jointing of short lengths of lumber for intermediate deckboards on pallets would affect the serviceability of the pallet. Report No. 2062.

Veneer Cutting and Drying Properties of Ponderosa Pine. Presents recommendations for the selection and handling of ponderosa pine veneer logs and gives data on conditioning schedules, lathe and slicer settings, and veneer drying schedules. Report No. 1766–12.

Estimating the Weight of Plywood. Describes a method of estimating the weight of plywood panels by summing up the weights of the various plies of veneer, the glue, and the water in the wood. Technical Note No. 260.

Metal-bonding Adhesives for High-temperature Service. J. M. Black and R. F. Blomquist. Reports on an investigation made for developing a metal-bonding adhesive with improved heat-resistant properties. Best results were obtained with a formulation of a phenol resin and an epoxy resin with certain heat stabilizers and catalysts.

Will Sales Be Tough for Junior? F. J. Champion. Discusses current trends in the lumber industry. Reprint from National Association Commission Lumber Salesmen.

Scarf Joints Prove Feasible for Large Laminated Members. Fred Werren. Reprint from Wood and Wood Products.

Bending Strength and Stiffness of Plywood. A. D. Freas. Presents data from tests of plywood with various thicknesses and numbers of plies and gives methods for computing the strength and elastic properties from the construction of the plywood and the properties of the individual plies. Report No. 1304 (revised).

Packaging Research at the U. S. Forest Products Laboratory. F. J. Champion. A historical review of packaging research work at the Forest Products Laboratory during the past 46 years.

Continued on pg. 26-A

EMPLOYMENT SERVICE

The FPRS Employment Service is operated without charge as a service to members. Companies or institutions with positions to be filled or individuals seeking employment may participate in this program by inserting a free ad in two consecutive issues of the FOREST PRODUCTS JOURNAL. Inquiries concerning employment listings or ads to be placed in the JOURNAL should be addressed to FPRS Employment Service, P. O. Box 2010, University Station, Madison 5, Wis. Correspondence is kept confidential.

Positions Offered

E-289—Field representatives for West Coast plywood manufacturer needed in Central and Eastern states. Activities: promotion, sales, technical service with travel in broad territory. Will be responsible for developing successful plywood markets. Age: 25–35. Some sales or promotion experience desirable. (Sept.)

E-290—Experienced man for sales work sought by manufacturer of domestic face veneer. Will operate from home office in Midwest. Excellent opportunity to advance to sales management. Reply giving personal history. (Sept.)

E-294—Sales engineer for well-established firm in the forest products industry needed by northwest concern. Product to be serviced is particle board. National travel to service accounts and contact customers. College training desired, preferably in forest products. (Oct.)

E-295—Research Technician desired, preferably wood technologist with experience in plastic overlays and wood finishes as well as wood products, plywood and adhesives. Primarily laboratory work in product development. Pacific Northwest. (Oct.)

Employment Wanted

No. 425—An M.S. Chemist with experience in large chemical research programs interested in creative position in chemical, wood products or mineral-related industry,—research, liaison or technical service. Has done work on physical chemistry, catalysis and rocket fields, supervised chemists and a pilot plant crew, with writing, speaking and contact experience. Available soon. Prefers New England, Northeast or North Central location. (Sept.)

No. 438—Technician with 23 years experience will accept position in U. S. or foreign plywood company. Experienced in plywood and adhesive research, quality control, technical service, plywood manufacturing methods, machining, supervising, and familiar with processing and gluing of exotic woods. (Sept.)

No. 439—Responsible position desired requiring drive, initiative, and ability to obtain results. Experienced as plant manager, with 28 years comprehensive engineering and executive experience in fields of mechanical, electrical, chemical, constructional, civil engineering and particle board production. Prefers position in particle board industry. (Sept.)

No. 440—Graduate in Forest Products seeks position in production management. Experience in manufacture of industrial products (boxes, crates, reels, and pallets) including supervision, job planning, container design, inspection and sales. Age 29. Prefers Southern location. (Oct.)

No. 441—Person with 25 years of managerial experience desires position as assistant project manager or assistant plant manager of particle board plant. Masters Degree in law and economics from J. K. University, Lvov, Poland, and 1 year of chemical engineering at Polytechnic Institute, Lvov, Poland. Will go any place in U. S. (Sept.)

No. 443—Position desired in forest products sales, distribution, or production. Graduate of Penna. State University with a B. S. in Forestry. 24 years of age and just completed two years of duty in the Army. (Oct.)

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HAND SHAPER AND BAND SAW →	Mark and band saw 50 minutes Set-up time 10 minutes Hand shape 83 minutes Rough sand—eliminate blend mark 83 minutes Finish sand 50 minutes **Total 276 minutes**	Mark and band saw 200 minutes Set-up time 10 minutes Hand shape 333 minutes **Total 543 minutes**	Band saw 250 minutes Set-up time 10 minutes Hand shape 500 minutes Rough sand 250 minutes Finish sand 125 minutes **Total 1,135 minutes**
ONSRUD AUTOMATIC SHAPER →	Set-up time 40 minutes Shaping time—multiple station form 15 minutes Finish sand 40 minutes **Total 95 minutes**	Set-up time 40 minutes Shaping time—multiple station form 125 minutes **Total 165 minutes**	Set-up time 40 minutes Shaping time—multiple station form 250 minutes Finish sand 125 minutes **Total 415 minutes**

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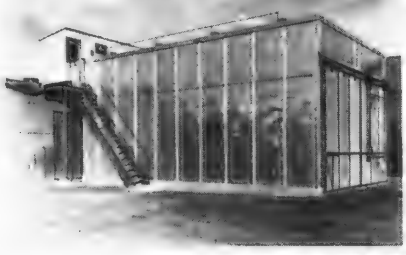

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FOREST PRODUCTS RESEARCH SOCIETY
P. O. Box 2010, University Station
Madison 5, Wisconsin

FPRS Forest Products Journal

Vol. VII, No. 9
September, 1957

Making Research Pay in the Lumber and Plywood Industries

ARTHUR L. MOTTET

Research Director, Long-Bell Division, International Paper Co., Longview, Wash.

There is a tendency to think of research only in terms of laboratory activity. The author attempts to get those concerned with research and development to be more conscious of the activity that precedes laboratory work and the commitments that are implied in completed laboratory work.

THERE HAS BEEN a growing interest in industrial research in the lumber and plywood industries. This interest had its beginnings in appreciable volume between the two World Wars, and since World War II has grown at an accelerated pace. Yet, the development of the industrial research arm of these industries is unquestionably slow and uneven. The latest surveys of company-financed research in the major industries of the U. S. show lumber and wood products industries at the bottom or near the bottom in magnitude of research activity, both in regard to number of companies carrying on any regular research activity and dollar volume ratio of research expenditures to sales.

This state of affairs is often deplored by those promoting larger expenditures for research, the implication being that the industry is not fully aware of the benefits of research. The question raised here, however, is whether the real cause of the slow development of lumber and plywood industrial research might not be uncertainty as to how to make research pay off. Any observer of development activity in these industries for the past two decades must concede that there has been a considerable amount of tentative probing in the direction of industrial research, even though this has not eventuated in any substantial volume of research programs in the industry. Obviously, if those firms which had conducted the initial sorties into true development activity could see the way through to a return on their research investment, the scale of research activity in lumber and plywood would have increased much faster than it has. The significant question then becomes why research has not been made to pay off more directly in the lumber and plywood industries, and what might be done to remedy the situation.

Expenditures for industrial research in the lumber and plywood industries, as in any other, are made with the expectation that the money expended will be recovered with profit. Investment in industrial research is in general the same as investment in any other form of business enterprise. The same factors of risk, expected returns, and alternative uses of available funds have to be considered. There are, however, such important differences in research as an enterprise, as compared with regular manufacturing and sales operations, that industrial research can be regarded as a separate business within a business.

Successful conduct of a manufacturing and sales operation by an industrial firm does not guarantee that it has the capability of carrying on a successful industrial research operation. A separate and distinct kind of technical and business know-how is involved and is essential to a satisfactory return on the research investment. The purpose of this paper is to discuss the important special points of conducting research as an industrial operation and the problem of making research investments pay off in the lumber and plywood industries. This is an area of thought that has not received appreciable attention in the forest products field, insofar as it may be ascertained in its literature.

Expenditures on Research in American Industry

It is beyond question that the total investment in research in the United States has paid off handsomely. According to Dr. Raymond Ewell, Director of the National Science Foundation, the U. S. as a whole has earned back $2,000 to $5,000 for every $100 spent for research and development in the past 25 years (1)[1]. The chemical industry is among those which have developed the research and development operation to a regular, systematic paying basis. Summarizing the over-all picture for this industry, Mr. Ronello B. Lewis (2) reports:

"Looking back, one could conservatively say that every dollar of research had generated two or three dollars of capital expenditure, 20 to 30 dollars of sales over 10 years, and three to six dollars of pre-tax profit over the same period. The ratio of profit to the research dollar was between a low of 3 to 1 and a high of 6 to 1, and this was true on both a pre-tax basis as well as after taxes."

The phenomenal success of industrial research of course does not provide any automatic guarantee that every investment in research will be profitable. On the contrary, when considered individually, research projects almost invariably are begun as high-risk ventures. Furthermore, there is no reason to believe that research effort should be equally productive in every industry and in every field in individual industries. The lumber and plywood industries often have been criticized for not spending more on research, without regard to the fact that the mere expenditure of large sums carries no assurance that the spender will share in the large returns which on the whole have characterized research spending.

The broadest study of research expenditures specific to the forest products industries was that reported by Kaufert and Cummings (3). (Table 1).

Another survey with some indicative value is that of the Harvard Business School (4). In this survey it was found that, of 308 responding firms

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[1] Numbers in parentheses refer to literature cited.

Fig. 1.—The first major step in research and development—conception, study, discussion, plans, decisions (expense: tens to hundreds of dollars).

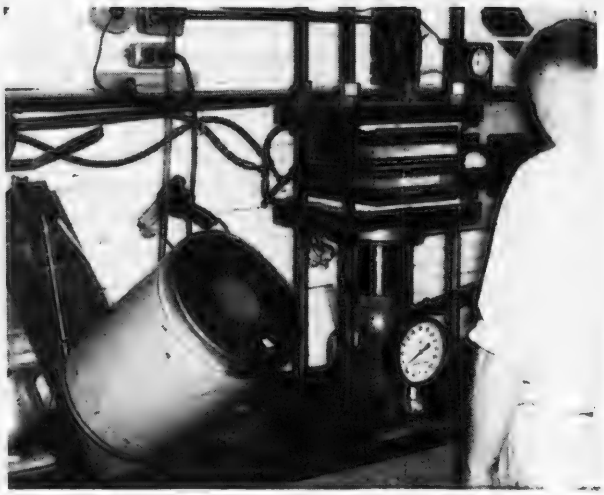

Fig. 2.—The second major step—laboratory-scale experimentation (expense: hundreds to thousands of dollars).

Table 1.—INDUSTRY EXPENDITURES FOR RESEARCH

Product Field	Approx. value of products shipped in 1952 Millions of dollars	Industry expenditures for research in 1953, company, association, and private	
		Amount Thousands dollars	% of Product Value
Pulp, Paper, and other Fiber Products	5,500	16,500	.30
Lumber and Lumber Products, etc.	6,000	5,000	.08
Wood Preservation	330	1,350	.41
Plywood and Veneer	570	1,600	.28
Miscellaneous	600	2,100	.35
Totals	13,000	26,550	0.20

Table 3.—RESEARCH EXPENDITURES OF 191 COMPANIES

Industry	Number of firms	1952 research expenditures, % of sales, median figure
All Firms	191	1
Food and Kindred Products	12	0
Textile and Apparel	9	0
Furniture	5	0
Paper, Lumber and Wood Products	14	0.7
Chemical and Allied Products	41	2.7
Petroleum and Coal Products	15	0
Rubber	7	0
Stone, Clay, Glass	6	1
Primary Metal	11	0.9
Fabricated Metal	8	0.7
Machinery except Electrical	12	1.1
Electrical Machinery	9	2
Transportation Equipment	10	1.1
Professional Scientific and Controlling Instruments	19	4.7

in the lumber and wood products industries, 38 per cent spent some money on research in 1952, but only 7.8 per cent maintained research organizations. In the latter figure, lumber ranked the lowest of 31 industries surveyed. Of this 7.8 per cent of lumber and wood products firms, 83 per cent were among the 20 per cent of largest firms. With regard to the amount of research spending as a percentage of sales, the figures are more sketchy. However, out of 10 reporting firms for the year 1951, the median figure was 0.2 per cent of sales. This is compared with other industries in Table 2.

In the same study, the research spending of 191 leading companies was reported as follows (Table 3).

There is a marked discrepancy between the Harvard and the Kaufert-Cummings findings with respect to research expenditures by lumber and wood products companies. This is no doubt due to the fact that the Kaufert-Cummings results represent the average of the entire industry, while the Harvard study tended to cover larger firms that tend to engage more heavily in research.

A broad sweep of the history of interest in research in forest products is given in another table by Kaufert and Cummings (Table 4).

U. S. Dept. of Labor statistics (5) and a survey by the Washington Institute of Technology (6) corroborate the foregoing and add to the general picture of research investment in the forest products industries as compared with other major American industries.

Although the trend in research and development in the lumber and plywood industries is definitely upward, the expansion can be characterized as uneven. A relatively small number of companies have undertaken research programs on a substantial scale and on an on-going basis. However, most have not attempted to enter the field, or at best have engaged sporadically in efforts that can be characterized as research and development. In such cases, the activity is pursued intensively in a specific field and is then abandoned when, as in the majority of cases, the specific aim is not realized. The lumber and plywood industry appears to be in transition between the original state of all industry in which new technical developments were undertaken as "one-shot propositions" when new ideas were proposed by individual inventors or promoters, and the state in which research and development is pursued as an organized and systematized activity.

There are other factors outside the question of profitability of research

Table 2.—RESEARCH EXPENDITURES AS A PERCENTAGE OF SALES

Industry	Number of firms	1952 research expenditures, % of sales, median figure
All Firms	1451	0.9%
Lumber and Wood Products	10	0.2
Food and Kindred Products	69	0.2
Paper and Allied Products	48	0.4
Industrial Chemicals	85	2.0
Drugs	68	3.1
Paints	31	1.9
Petroleum Products	43	0.6
Stone, Clary, Glass	34	0.9
Primary Metal	45	0.4
Fabricated Metal	142	0.6
Machinery except Electrical	175	1.0
Motor Vehicles and Parts	26	0.6

Table 4.—THE INCREASE IN EXPENDITURES FOR FOREST PRODUCTS AND UTILIZATION RESEARCH FROM 1926 TO 1953

Year	By Industries	By Public Agencies	Approximate Total	Approx. Per cent of Product Value
1926	$ 900,000	$ 700,000	$ 1,600,000	.04
1937	$ 2,500,000	$ 800,000	$ 3,300,000	.07
1953	$26,550,000	$4,450,000	$31,000,000	.24

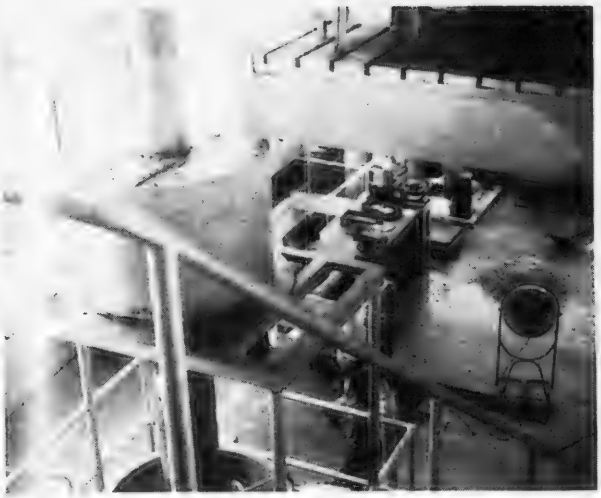

Fig. 3.—The third major step—pilot- or semi-plant experimentation (expense: thousands to hundreds of thousands of dollars).

Fig. 4.—The fourth and last major step—commercial development (expense: tens of thousands to millions of dollars).

that no doubt have helped to establish the scale of investment in research in the lumber and plywood industries, such as size of companies, permanence of operations, and customs and traditions, but these are outside the scope of this paper.

Definition of Research

Perhaps a discussion of the problems involved in making research a profitable adjunct to lumber and plywood manufacturing would be facilitated by a definition of what is meant by industrial research. The soundest definition is probably that offered by Hertz (7) when he defined research as, "the application of human intelligence in a systematic manner to a problem whose solution is not immediately available." Industrial research would then be that research carried on by or for an industrial firm. The objectives of industrial research are generally to improve present products and processes, find new applications for present products, or to develop new products and processes, all for the purpose of protecting present profits and realizing additional profits. It is organized application of scientific knowledge and scientific method for industrial ends.

Industrial research is not to be confused with the other important industrial activities of engineering, quality control, trouble-shooting, and technical service, although the dividing line between these activities and genuine research is not always clear-cut.

Industry-financed research is generally considered to fall into three main categories: 1) Basic—research conducted to uncover new scientific knowledge within the general area of the company's interests, but without any apparent connection to commercial application; 2) Applied—research conducted for specified end results relating to commercial application and which generally starts with information obtained from basic research; 3) Development—taking information developed from laboratory and pilot plant research and organizing facilities, both manufacturing and sales, for full-scale commercial application.

Perhaps it would be more useful for the purpose of organizing a practical research operation to classify industrial research in a somewhat different way:

1) Pre-laboratory Research: The original generation of an idea, discussion of possibilities, initial calculations and other paper work, and the making of a decision on whether to follow up with laboratory work.

2) Laboratory Experimentation: The performance of experimental trials and tests on a laboratory scale.

3) Pilot Plant and Semi-Plant Operation: The testing and evaluating of ideas on a scale intermediate between laboratory and full-scale operation.

4) Commercial Development: The adaptation of pilot-operation findings to full-scale commercial operation.

The implications of this more or less chronological division of the course of any industrial research project will be discussed later.

When a company decides to undertake industrial research, its management immediately has to deal with three fundamental questions of policy: 1) How much to spend on research. 2) Directions in which research efforts are to be expended, and 3) How to establish and maintain an effective research and development arm of the company.

How Much to Spend on Research

The decision as to how much to spend must necessarily vary tremendously according to the circumstances of the individual concern. The science of determining what volume of research represents the optimum for the future success of a company is so far only in its embryonic beginnings. The decision must still depend to a great extent on managerial intuition after all the factors of size of the company, financial status, competitive situation, current manufacturing and sales problems, and so forth, have been assessed. In addition to these, there are a number of other considerations which have a broad bearing on the decision, and it may be worthwhile to discuss them as a step toward a more exact method of deciding what should be spent on research.

The factor in the decision which most quickly comes to mind is the factor most commonly used as a yardstick in comparing research spending—the ratio of dollar volume to sales. The tables in the forementioned surveys of research spending in terms of percentage of sales have some value as a rough guide as to the over-all range in which research spending has been able to bring a return. However, as a general measure for assisting individual company managements in the decision as to how much to invest in industrial research, this method has serious shortcomings. It does not take into account the extent or cost of the operations performed on the product sold, or of the value added in manufacture.

An industrial operation in which raw materials are purchased at a low price and in which many costly operations are performed to greatly increase the value certainly in general would afford more opportunity for profitable research investment than industry which purchases its raw material at high prices and adds relatively little

to the value of the material in the conversion operation.

The cost of operations performed would seem to offer a better rough measure of research and development possibilities, and value added in manufacture would offer a measure of capacity to support research expenditures. These two factors are the basic components of profit, which also could be logically used as a reference base for estimating optimum research expenditure, inasmuch as investment in research and development in the long view is simply the plowing back of a portion of returns from an enterprise in the expectation that such an investment will at least help to insure the perpetuation of the returns or result in over-all increased returns. As a year-to-year measure of a research budget, however, percentage of profit is defective in that there may be times when declining profits could be properly taken as a signal for increasing the industrial research investment. In addition, in some chronically low-profit situations, research may be essentially what is needed to bring in better returns.

There is another frame of reference for research spending which in the long run should be the controlling one in the lumber and plywood industry. This is the timber and timber lands owned or controlled by the individual concern. The discretionary income of a company living from hand to mouth on purchased timber under current conditions is necessarily heavily committed to the acquisition of more timber simply to stay in business. The fact that investment in research tends generally to be long-term greatly circumscribes research and development activity in such a situation. Fundamentally, research and development associated with lumber and plywood manufacture goes back to the annual volume of wood available from forest land managed on a sustained yield basis, or on the productivity of forest land. Therefore the greater the volume of timber held by the company, or the greater the area of land under forest management, the greater will be the magnitude of justifiable expenditures for research.

Another factor is the apparent opportunity existing at any particular time for realizing a return on specific research investments. This could be called the opportunist school of thought. The ability to promptly exploit the opportunity depends in large measure, however, on the prior existence of a working research program. The factor of opportunity therefore represents possibilities of fluctuation in an already existing program, rather than an on-off type of approach to research and development. Rather wide fluctuations from year to year in the annual budget for research need not be considered necessarily as erratic behavior, if it is part of a consciously applied strategy which takes into account that development opportunities do not necessarily make their appearances evenly.

An important element associated with the decision on volume of research spending is the steeply progressive increase in the cost of a project as it moves from the pre-laboratory stage into commercial operation. For example, $100 worth of pre-laboratory work might result in $1,000 worth of laboratory work, $10,000 worth of pilot plant experimentation, and $100,000 worth of new plant investment. This should not affect the long-run expenditures for research so much as it does the year-to-year budget. Each stage of industrial research carries an implied commitment to go on with the succeeding stage if the indications are sufficiently promising. It is entirely possible that in certain years a research group will be concerned more heavily with the more expensive phases of projects, and in other years with the less expensive phases. Therefore any research and development spending has to be carried on with the perspective of several years.

The problems of determining the magnitude of a research program are discussed at considerable length by Hertz (7). Further discussion is also found in Marvin's work (8), where he gives concrete explanatory examples to illustrate the statement:

"The appropriation of funds for research should be based upon recognition of the potential contribution of research and tempered both by the willingness of the firm to accept responsibility for expansion and by the ability of the firm to finance research over a relatively indefinite period of years."

This subject is also touched on in the chapter on The Research Budget in Furnas' book (9). Dr. Yale Brozen has given an excellent review of the over-all picture of research investment in industrial laboratories in an article entitled, "The Economic Future of Research and Development" (10).

Direction of Research

The proper selection of projects is of the utmost importance in making industrial research pay. Any two persons knowledgeable in the technology of lumber and plywood manufacturing could sit down together and list within an hour's time literally dozens of subjects on which research effort could be expended, subjects relating to manufacturing and product problems whose solution could conceivably result in extra profit in these industries. The cost of research that would be represented by a list prepared in even such a short time could easily run into hundreds of thousands of dollars. It is reasonable to expect that the individual items in such a list would vary tremendously both as to profit potential and ease (or cost) of solution.

It is a further research fact of life that in any list of promising ideas, only a small percentage ever prove to be valid. A large part of any research program consists of testing and discarding what prove to be unfavorable leads. The profits from the small per cent of successful projects have to carry not only the cost of the successful projects but also the cost of the preponderant number of unsuccessful projects. It is apparent that a research enterprise will operate "in the red" if the proportion of unsuccessful projects becomes too large. The problem of selection is then to "smell out" those relatively few ideas which have a large profit potential, and not handle too many unprofitable ones in the process.

There is also an inverse aspect of the process of selecting projects which is equally important, and that is determining when to drop a project. Persistence, or stick-to-itiveness, is not necessarily a virtue in industrial research. As information is accumulated in the course of a research project, new bases for revaluation of the prospects for successful solution of the problems involved and of the over-all profit potential are constantly provided. The "overhead" costs of unsuccessful projects can be kept to a minimum only by recognizing unfavorable leads as early as possible. This is particularly important in view of the steeply progressive increase in cost of carrying a project as it passes through the forementioned successive phases. The selection process is therefore a continuous one that covers not only new projects but also those under way.

The actual mechanism of selection and rejection of research subjects is closely related to the third major question of industrial policy—how to establish and maintain an effective research and development arm—and will be dealt with in more detail in that section.

The problem of selecting research subjects has received considerable attention in the general literature on the methodology of industrial research. Discussions of this phase of industrial research policy can be found in the books by Hertz (7), Marvin (8) and

Furnas (9). A method of evaluation of research projects in which economics receives special emphasis is discussed by Gibson in an article, "Techno-Economics—A Revised Check and Balance for Management of Industrial Research Programs" (11).

How to Establish and Maintain an Effective Research and Development Arm

After the critical decisions as to what a company should invest in research and development, and as to what areas of research should be concentrated upon, there remains the equally critical problem of carrying out the program successfully. Several important aspects of this part of the problem can be listed as follows:

1) Building a winning research and development team.

2) Providing the requisite physical facilities.

3) Selecting the most promising and potentially most profitable research projects, and conversely discovering and dropping the inevitable unprofitable projects as early as possible with minimum expenditure of funds.

4) Integrating technical research & development activities with market investigation and development.

Building the Research and Development Team

Because such characteristics as intelligence, ingenuity, and originality—in short, creativity—play such an important role in the successful solution of research problems, it need hardly be said that individuals high in natural aptitudes for scientific, engineering, and technical development are an absolutely essential foundation for successful research and development. No matter how favorable all other aspects of the research picture, research expenditures are almost certain to be a waste unless the work is in the hands of highly creative persons. The importance of building a research team with capable individuals cannot be over-emphasized.

A second essential in relation to the competence of research personnel is of course actual knowledge in the type of work at hand, whether it be chemistry, wood technology, mechanical engineering, and so forth, as evidenced by appropriate college degrees and experience in the field. Inasmuch as this is an obvious requirement, it is mentioned only in passing. There is another aspect of training, however, which deserves attention in the research enterprise. Research and development skill as such is in part learned. Therefore, prior experience and record in research, whether in college thesis work or subsequent experience, are important considerations. Because research in American industry is expanding rapidly, there is a chronic shortage of research recruits. And because the lumber and plywood industries do not have any tradition or standing in research, they have an especial difficulty in attracting the more capable, research-minded young people graduating from the colleges and universities. This can be partially compensated for by a conscious effort on the part of a firm to develop creativity in its research personnel. A general method of accomplishing such a purpose has been pointed out by Mr. E. K. von Fange of the General Electric Co. in his article, "Developing a Useful Imagination" (12).

A third essential in building a productive research and development team is creating a favorable climate for research. Because research productivity is so completely dependent on research worker creativity, favorable climate for research is synonymous with favorable climate for creativity. Porche of Armour and Company (13) has briefly, though comprehensively, summarized the conditions favoring productive research and development work. He listed a few rules of thumb which can well be quoted here:

"1) Creative work is always given spontaneously. It cannot be extracted.

2) The creative worker must be made secure and encouraged to develop self-confidence to the maximum.

3) The creative worker must have an adequate background of factual knowledge in his field of work. He must also be thoroughly familiar with the policy framework within which he can operate.

4) The creative thinker must be free to communicate with those having useful knowledge, points of view, and ideas.

5) Warm, encouraging acceptance on the part of the supervisor always stimulates creative output.

6) Some guidance must be supplied in the form of constructive criticism. Many creative people need the reassurance of gentle tension on the reins.

7) A feeling of urgency on the part of the administrator is perceived by the researcher and will be imitated. Urgency must not be confused with anxiety.

8) Competitive drives can be utilized to create tension or a feeling of urgency. This technique is well adapted to use in group situations. Excessive competition, however, has a negative effect."

In all of the foregoing, it is assumed that all the usual requirements of a smooth-running organization are fulfilled—well defined lines of responsibility and authority, proper division of labor, effective lines of communication, and proper provision for the mechanical aspects of organizational functioning.

Providing Physical Facilities

This aspect of the research policy problem is definitely the simplest. When the foregoing problem of building a good research team has been effectively solved, the question of research facilities is almost automatically at hand. The research arm will have a detailed knowledge of the needs and conditions of the firm of which they are a part, a sense of urgency for the early and economic solution of the research problems at hand, and an expert knowledge as to the equipment required for efficient work on the problems. This, coupled with the managerial recognition that, just as jet aircraft has given man a tremendous capacity for transportation over that possible with the ox cart, so proper scientific research equipment gives greatly extended power to cover research ground. The answer therefore, would seem to be to provide whatever is proper for the work at hand, subject of course to the over-all budget picture. The range of problems that can be effectively worked on with just a beaker and Bunsen burner is definitely limited.

Selecting Profitable Research Projects

The importance of selecting those projects that are most likely to pay out satisfactorily was emphasized earlier by listing it as one of the three fundamental aspects of a company research policy. The subject also comes under the problem of establishing and maintaining an effective research and development group, because the actual mechanism of selection of projects is deeply involved in the functioning of the group and in its relation to the other arms of the company of which it is a part. The end results of the selection are of tremendous interest because the research problems most desirable from the research group viewpoint are: 1) Those solved most quickly and easily and at least cost, and 2) Those the solution of which yield large and obvious returns to the company. These two factors establish the measure of success or frustration of a research group.

It does not follow, however, that the views of key research persons can or should necessarily predominate in the choice of projects. These views must play an important part, to be

sure, but only one of several important parts. The reason for this goes back to the ultimate nature of research. Research, or the development of new knowledge, always must start from known facts, or from old knowledge. Only a portion of the old knowledge that should form the basis of selection of research projects can be held even by the most competent industrial research group. A great deal of such knowledge resides in other sections of an industrial organization, such as in production supervisors, the production men themselves, inspectors, and salesmen. The problem, then, is to bring all the available information from these various sources to bear in the selection of research projects and thus increase the probability of doing work that will meet real needs of the company and maximize the probability of ultimate profit. In short, profitable industrial research is not likely to be achieved in an ivory tower.

The first essential is that the selection function be carried on consciously and systematically. The second is that effective lines of communication be established, regardless of the organizational chart or pattern by which this is accomplished, so that information from all available sources can be brought to bear in a decision. This concentration and synthesis of information regarding the research needs of an industrial concern can take place at top-management level through a management research committee. Research ideas would flow into this committee from the sales department, production department, and other sources as well as from the research department. The research project decisions would be made on the basis of this information.

The concentration and synthesis can also occur at the research administration level or even to a large extent at lower levels in the research organization, if the inter-departmental communication lines are functioning properly. The most effective arrangement depends greatly on the nature of the individual concern, its size, organizational set-up, and the interests and qualifications of the individuals occupying the various posts.

In the growing literature on research methods and practices, considerable attention is paid to the subject of selecting projects. A comprehensive discussion of the problem in practical terms, one likely to be useful to lumber and plywood firms engaging in research, is that given by C. G. Harrel (14). Another good summary is that given by Leermakers (15). Robert N. Anthony and John S. Day (16) deal with top management functions in this field. Two committees in the Commercial Chemical Development Association prepared excellent discussions of this subject in relation to the chemical industry (17), but their findings are equally applicable to research and development in the lumber and plywood industries.

Market Research and Development

The returns on an investment in a new or improved product of course cannot be realized until the product involved is sold in requisite volume and at adequate price. It is conceivable therefore that all the technical aspects of a research and development project might be successfully executed from the original conception to the final commercial production, and yet be a total failure if the sales side of the picture has been neglected.

The question of markets and sales all too often comes into detailed consideration only as the last step in technical development, when the production facilities are installed and the product is ready to sell. The proper relationship of market or sales research to the technical phase of new product development is shown on the cover. Although this chart refers to the chemical industry, the relationship shown is equally valid for the forest products industries. Market research and development should move parallel with technical research and development the entire way from the original conception of a new product idea to commercial production. The data upon which fundamental decisions must be made from time to time on product development, that is, whether to abandon, continue, or accelerate, are incomplete without the best market research data that can be furnished. Market research bears the same relationship to technical development as the social sciences do to the physical sciences. It is not as exact a science; nevertheless, whatever information can be gotten through this phase of industrial research is of critical importance to success in new product development.

Various methods of accomplishing this phase of research are possible. Some companies may accomplish this function through its regular sales department and by maintaining a close and permanent liaison between its research and sales department. Others may have a special market research group or a special products department within the sales department or research department to conduct market evaluation studies and carry on the initial introduction of a new product into commercial sales. Still another means of carrying on at least part of the market research activity is through the use of the growing number of market consultants. Because this is an area that is still in an even more primitive stage of development than forest products technical research, much room for progress remains for developing effective methods.

Summary

The over-all experience of industry during the past 50 years has shown the research and development segment of industrial enterprise to be immensely profitable. The lumber and plywood industry has not as yet been able to show the large returns on research investment as have been realized by other industries, and the scale of investment in industrial research and development in the lumber and plywood industry ranks the lowest among the major industries of the United States.

Conscious attention to the subject of research and development as to the methods and conditions under which it can be made to pay should open the road to more profitable research and development enterprise in the lumber and plywood industry. Particular attention should be paid to research policies and methods employed in those industries which invest heavily in research and realize large returns on their investments.

The three fundamental research and development questions that have to be answered by those charged with the responsibility of company policy are: 1) the amount to spend on research, 2) the directions in which the research efforts are to be expended, and 3) the means by which an effective research and development arm of the company can be established. The important elements in establishment of an effective research arm include competent personnel and a favorable climate for research, adequate physical research facilities, an effective mechanism for distinguishing between favorable and unfavorable development projects, and proper attention to market research and development along with technical research and development.

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Waste Control in Lumber Remanufacture[1]

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More reliable information on processes is needed, and greater use should be made of existing methods of analysis. Understanding of the meaning of "variation" is absolutely essential, along with the concepts of a controlled process and process tolerance. Principles of quality control of waste in lumber remanufacture are presented and examples given of using statistical analysis and sample evaluation.

Introduction

LUMBER PURCHASED by remanufacturing plants for conversion into finished products is a non-uniform material. Variations of the raw material together with those of machines and machine operators produce many complex problems in a production organization. Past studies, however, show that the resulting variations can be statistically analyzed and quality control instituted to keep the variations within reasonable limits.

It is the belief of the author that a few important concepts essential in production problems analysis are often neglected. The information available on efficient lumber conversion is widely scattered in literautre relating to wood working in general. Some of the most fundamental facts relating to material utilization are found in the National Hardwood Lumber Association Rules for grading lumber (9).[2] Authors of magazine articles and technical papers have provided facts and opinions.

The following list of cardinal principles and suggestions will serve as a guide to analysis and control of waste in remanufacture of lumber:

1. Study boards by grades for expected yields and compare with actual results (3,4).
2. Select grade or grades of lumber to match economically the dimension produced (3,4).
3. Grade boards for rip or crosscut as first sawing operation (3,4).
4. Combine grades of dimension in one set of cuttings (17).
5. Cut several lengths in combination that fit general characteristics of usable areas found in boards.
6. Saw random width material along with fixed widths (17).
7. Use a glue jointer rather than a rip saw to produce suitable gluing surfaces on rough board edge after surfacing.
8. Glue from rip-saw to eliminate jointing waste. (Exception as in point 7)
9. Don't overconveyerize, highly mechanized operations run at great speed may lead to greater waste of raw material.
10. Watch for excessive overruns of parts, an occasional shortage is desirable (17).
11. Dramatize waste information By use of charts; Show costs where possible.
12. Increase labor costs a little to save a lot on lumber cost.
13. Pay a bonus for better yields.
14. Don't give production incentives without regard to yields.
15. Check cutting bills and improve specifications (12).
16. Keep machines in good running order.
17. Determine allowable waste by product classes.
18. In match ripping panels, place wider stock in a position for ripping leaving a piece sufficiently wide to serve as the edge piece of the next panel.
19. Adopt a questioning frame of mind.
20. Use control charts on lumber conversion operations (8).

References given at the end of this paper may be used to obtain amplification. Some viewpoints on efficient operation are controversial. However, differences of opinion tend to disappear when specific cases are considered.

Many of the suggestions given above may be used to some advantage in most operations. In the long run, however, the most reliable and productive source of guidance is your own mill. Someone else's experience may be used as a rough guide in developing your own plan of action. Nevertheless, home plant investigations, your own experiences, serve as the best guides for action in a given situation. It is from these investigations that the answers

[1] ...sented at North-Central Region Meeting, Nov. 15–17, 1955, in Chicago, Ill. At that time, the author was on the faculty of the State University of New York College of Forestry, Syracuse.

[2] Numbers in parentheses refer to Literature Cited.

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can be found to the questions of when, where, how, and how much.

Relatively few of the references provide assistance in improving methods of evaluating processes. For example, even though the suggestion may be given that overruns shouldn't be excessive, rarely, if ever, is the means given for determining what is an excessive overrun. There is, then, a need to discuss evaluating methods. The viewpoints given here on obtaining information on rough mill operation do not differ from the general case in production.

Understanding the Process

Every operation possesses unique features. Each plant is different from any other. Furthermore, no process is static, remaining the same from hour to hour. The differences between, and variations within complex rough mill operations require that the best methods available be used in evaluation to bring about steady, high-level performance. The development of better methods depends upon thorough study of small parts of the overall problem, recognition of the importance of variation, and an understanding of the concepts of a process tolerance and of a controlled process.

Study of Small Parts: The engineering principle of subdividing the problem for study has been followed by many investigators in the work done in the analysis of lumber yields (3,4,9,15,18,19). Much more work should be done within individual plants to learn the part played by raw material characteristics in the process results. Lumber grade requirements should be fully considered in studies to determine yields in various products. Yield figures charted in relation to raw material and conversion methods offer aid in selecting lumber of the most suitable character to produce a given order. Although the work may be tedious and the cost of the information relatively high, the savings to be effected are sufficient to offset these disadvantages.

Other factors influencing production should be separated out for study. Examples of the analysis of subdivisions of the overall problem are given in the discussions of process control and process tolerance. These discussions are largely dependent upon a concept of variation.

Concept of variation: Yield figures have been obtained within many plants by lumber grades. The Timber Engineering Company (10) reported on a survey made to determine the average yields from grades and species used in furniture manufacture: "It was evident that much additional work should be done by the users of hardwood lumber to determine accurate yield statistics".

Let's assume that in a given plant that the yield data do accurately represent the production preformance in the rough mill. In order to determine whether the yields are as great as they should be some comparison would have to be made. A reasonable test would be one that compared production figures with yield figures obtained by actually measuring sample boards for maximum product yield. Measured yields of this kind have been obtained with results that were verified by yield figures arrived at in cutting the same boards into the product considered (10, 15, 18).

Suppose that such a comparison were made with results of 66.1 per cent on the average in the mill and 70.2 per cent sample yield, a difference of 4.1 per cent. The question of acceptance of such a difference as this has to be dealt with. Some action would be taken to correct the discrepancy if it is not acceptable. A supervisor, when given the above report, would probably tell his saw operators that they were doing a poor job, that they should average 70 per cent yield. He would also set up a closer checking system to see that this was done.

Has the supervisor any real basis for his decision? A restatement of the question would be, how reliable is the average of the sample. The degree of confidence that may be placed in an average is determined by the variation that exists in individual contributions to the figure and the number of the contributors measured. For the most part variation within samples taken to determine yields is not determined or reported. The probability aspects seem to be ignored.

Reference may be made to the American Society for Testing Materials Manual on Quality Control of Materials (1). Here may be found information on minimum requirements in presenting data such as that necessary in study of yields. The two most pertinent requirements are:

"1. Present as a minimum, the average, the standard deviation, and the number of observations. Always state the number of observations.

5. Present relevant information on precisely (a) the field within which the measurements are supposed to hold and (b) the conditions under which they were made."

Why are these requirements given? The answer is the fact that the average figures above provide little information. No confidence can be placed in averages unless the sample size is given. The sample may have been made up of a dozen or of only two boards. Even knowing that a large number of boards was involved isn't satisfactory. There still is no indication of how individual boards vary as to yield and therefore how averages of such samples may vary.

A more complete report on the above sample may have shown that 20 boards had been measured and the standard deviation for the yield measurement was 9.87 per cent. With this information, we may explore the matter of confidence using a recommendation of ASTM, (1), again, or presenting ± limits of uncertainty of an average. The limits are ± a given number of standard errors depending upon the confidence desired.

Two standard error limits for the average determined by use of an estimate of its variation are 70.2 ± 4.73 per cent. This means that we can expect an average of a sample of 20 boards to be as much as 4.73 per cent different from the average of all boards of the same class or grade as often as one in 20 times by chance alone. The difference of 4.1 that was obtained would be expected in sampling as often as one in 10 times, that is, it is not significant. The sample information does not require an attempt to get operators to turn out better yields. They may be doing as well as could be expected.

It may be decided that the sample is too small and a larger sample should be taken. Suppose that the initial sample had contained 100 boards with an average of 68.5 and a standard deviation of 7.45 per cent. Comparison of this result with past experience in the plant would show that this difference of 2.4 per cent between averages should be expected about once in 500 times in sampling. The one in 20 probability limits for the sample average would be 68.5 ± 1.46 per cent.

So we see that the supervisor of the rough mill would likely have been more inclined to take action to get higher yields when evidence was less in favor of it if only the averages had been reported to him.

Two actual sampling results have been compared to show the significance of the differences obtained. The results were in samples of 4/4 No. 1 Common which were measured for percent yield in random width materials as indicated:

Cuttings	Maple (18)	Walnut (1	D.F.
47" only	av. = 62.8 SD = 14.68	av. = 52.	100
47" + 4 shorter lengths	av. = 18.3 SD = 7.51	av. = 76.3	52

The number of maple boards was 133, walnut 341.

The probability of obtaining these differences in sampling from the same class of material is the same, one chance in several thousand. The probabilities are determined by comparing the difference in averages with the standard error of the average for maple. Both sets of figures comparing maple and walnut give the same degree of confidence in a statement that the two species aren't the same in respect to the yield in products considered.

Again, the importance of differences in averages could not be determined without a measure of the variation present in the sample.

Recognition of variation and its importance is vital to success in understanding figures. Realistic decisions can be made only when such information is available. Variation is the very heart of the problem of comparison involved in evaluating and controlling processes.

Concept of a controlled process: The most realistic objective in rough mill utilization is to control the process of conversion so that yields are maintained at a high level continuously. A controlled process is one in which variations are no greater than those we expect, than are explainable by the laws of chance. The matter of expectation is of vital importance. Yield variation greater than expected by chance alone calls for action leading to improvement in worker performance, in selection of material, in machine performance, or finally in a combination of the factors having influence on yield. What we can reasonably expect to happen is determined entirely by our knowledge of the process. Action, following failure to measure up to expectations, that leads to improvement, depends upon up-to-date information collected frequently in a continuous manner. Annual yield averages only are of little use. Monthly figures are but little better and weekly information is insufficient. Daily reports come close but hourly checks showing variation approach the ideal combination of low information cost, practicability and usefulness. The control chart technique provides a means of solving some utilization problems in yields. In order to control activities influencing yields, action on out-of-control conditions must be immediate, therefore hourly information is necessary.

MacMahon (8) reported the use of a control chart in connection with cross cutting waste. The following example is an extension of the idea in which the ripping operation was studied. In this case clear-one-face, random-width material for edge gluing was being produced on a straight-line rip raw operated at 93 feet per minute feed. The operator was required to rip out defects and match rip.

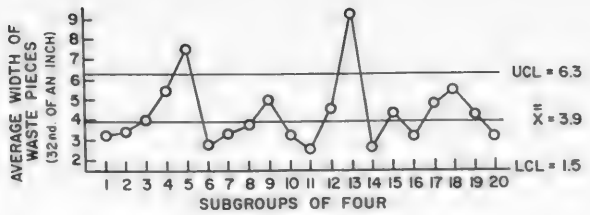

Fig. 1.—Control chart on waste at rip saw.

Waste of over 18 per cent has been reported as occuring in ripping operations of this kind (17). The amount of waste expected here depends in part on the job of defect removal at the cross-cut saw, of course. However, the control desired is independent of the cross-cutting.

In this operation random width pieces averaged three inches wide. The operator was throwing away pieces cut out as defective that had, on the average, acceptable material almost 4/32 of an inch in width for the full length of the piece. The loss of usable material was four per cent of that remaining in production at this point. This is an appreciable amount and may be reduced.

Samples of four pieces at a time taken at random from discarded material were measured to obtain averages and variation used in charting the results shown below.

The control chart (Fig. 1) makes use of a process average and its variation. It shows how much waste is occurring and in a manner that allows effective action to be taken when the waste is excessive. There are out of control points showing excessive waste for samples 5 and 13. Of course, the chart gives no information on what is the cause. It gives the very important information of when the cause is active. In this case the operator made unacceptable errors.

A great advantage of the chart is that it provides a most suitable means of determining when attempts to improve the process are effective. Machine and man are the factors being controlled here. The chart also fulfills the requirement for dramatizing waste.

A first effort in application of the control chart to ripsaw waste led to an operation in which a high-cost species was being cut for table tops. It turned out that in ripping at the lowest feed rate possible, in taking plenty of time to look over the material before making a cut, and in using good judgment there was no appreciable waste to measure. There was a question of under production however. There probably are many well performed operations where a chart would not be worth its cost. On the other hand, there is probably a rather large number on which the chart could be used to an advantage.

It may be of interest to know that in the operation of ripping table tops the operator wasted about two per cent of usable material quite unnecessarily in spite of his excellent performance in respect to the waste on which the chart was to have been used. The waste was due to a management decision which if modified would lead to a better product and a somewhat broader application of a control chart on the process. The operator was told to maintain pieces as wide as possible and he wasted material by not ripping wide stock in matching panels.

Concept of Process Tolerance: The control chart is a tool developed from the general concept of variation. Fig. 1 shows the waste variation or tolerance limits inherent in the process. Each process has such tolerance limits. This general concept is applicable throughout a wide range of production problems.

The need for specifications results from variation. A universal production problem is that of setting specifications. To be realistic, they should be based on more than a study of subsequent assembly or service requirements. In each case there are natural process tolerances that exist due to variation imparted by factors of production. The capability of a machine or process may be expressed as a tolerance for use in setting up specifications. Length and width allowances for rough dimension should be established with consideration for machine and process tolerances. In another area, overages allowed for order quantities should be worked out following study of process variation.

In one furniture plant the average overrun on a table leg was 5.3 per cent in lots of 100 pieces where allowance was 10 per cent. The data:

Overage in lots of 100	Frequency
2	1
3	3
4	7
5	13
6	10
7	6
8	2
Total	42

The average is *5.3*, standard deviation *1.39*, three standard deviation limits 1.13 to 9.47. On the average, extra table legs cost $1.50, overages are scrapped, and the estimated cost of rerun to make up a shortage is $22. The present cost of the overage is 5.3 x $1.50 = $7.95 per one hundred legs. The percentage allowance could be reduced to result in an average overrun of 4.0 per cent with a probability that a shortage would occur less than one time in 100. A conservative estimate of the cost with this average would lead to 4.0 x $1.50 = $6.00 plus .01 x $22.00 = $0.22. The saving per lot of 100 would be $1.73. In the above case management wasn't even requiring a record of overages and shortages of parts. A control chart for number of defects would be worthwhile in this case.

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Changes in Methods to Conserve Lumber[1]

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Using outmoded methods in face of increasing lumber prices is quite costly. To correct this, a study was made of causes of seasoning defects and new stacking methods were employed. New approaches to drying and bending also contributed to increased yield and lower costs.

Introduction

THE CONSTANTLY INCREASING COST and the decreasing quality of the lumber generally obtainable are, or should be a matter of concern to everyone in the industry. The present tendency seems to be more towards the use of lower grades of lumber and what were formerly less desirable woods rather than towards conserving and getting the utmost out of the better and higher grade woods.

In seasoning, attention seems to be concentrated on the kiln drying of those woods through better kilns, education of kiln operators, new and faster schedules and various quality control checks. If the kiln operator turns out a season checked or honeycombed lot of lumber he immediately is put on the spot. But is it always his fault? Is he having to dry lumber that was seriously damaged long before he had it in his charge?

Damage to lumber can begin the day it is cut. Within a short period lumber can be damaged to such an extent that the most expert kiln operator with the finest kiln can do nothing for it. Is it realized that rough lumber is a valuable material and treated accordingly?

This fact is often overlooked by both management and employee, because they are so used to lumber as such. Not until they start to cut it into little pieces do they pay much attention to it. But what about it from the time when it was first sawn until it is ready to be cut up?

At the factory increasing awareness of this has developed because of the type of product, a solid wood chair, built under strict specifications and subject to rigid inspection before acceptance by the purchasing agency.

Lumber is purchased through invitation to bid and acceptance of the bid. Because of this lumber is received from many producing areas, concentration and wholesale yards. There is quite a variation in quality, specifications for species, and grade for grade. Lumber is bought with N. H. L. A. inspection and certificate.

The factory was established about 20 years ago and staffed with supervisory employees with professional woodworking backgrounds. Consequently, many of the operations were carried out in the traditional manner. In those days lumber of high quality was plentiful and Firsts and Seconds could be and were bought for less than $100/thousand delivered to the yard.

[1] Presented at the Ohio Valley Section Meeting May 17–18, 1956, in Jasper, Ind.

The Author: Ralph W. Shepherd has worked as an installation and operating engineer for several dry kiln manufacturers since 1922. He has been connected with kiln evolution from the "hot box" to the modern kiln.

Is lumber treated any better today? Perhaps in a few cases, but in most it is not.

Inspired By Queries

Often a statement or a remark will lead to a different type of thinking. In this case there have been two such statements, one by Mr. C. D. Dosker at the Ohio Valley Section meeting at Cincinnati, the other a question by Mr. Ray Reitz at the Louisville meeting about two years ago.

Mr. Dosker said that the woodworking industry was afflicted with "Grandpappyitis". In other words, too easily satisfied to go along with the old ways. Machining and finishing operations, in many cases, are being improved and revamped through the use of better machines. New glues and gluing techniques, finishing materials and methods of application are other examples.

But in the field of lumber seasoning, how much progress actually has been made? True, mechanized handling and stacking of lumber is found where volume is a factor and labor costs are high. The internal fan kilns with controls and the use of higher temperatures in kiln drying are important advances in the rough lumber field.

But in the face of these advances how much fundamental thinking has been changed? There are many mills and factories today where yarding, kiln drying and storage have changed very little throughout the years.

At the chair plant the woods used are chiefly birch and oak with some maple and walnut. Prices are now 2½ times and over those paid twenty years ago. When a car of Common and Better is received the percentage of F. A. S. is substantially below that of similar purchases 20 years ago. The problem then is increased primary costs and decreasing quality.

What is being done to counter these changes? In the face of these conditions it has been found that these two widely spaced remarks tie together. The first by Mr. Dosker of the "Grandpappyitis" type of thinking and the question of Mr. Reitz, "Why are yard stacks sloped from front to back?", prompted an investigation.

The lumber yard is small in comparison with many, with an air drying capacity of approximately 500,000 feet. Until Mr. Reitz asked this question the stacks on the yard were the conventional type. They were of good elevation, sloped from front to back and covered with several layers of low grade boards. This is the way stacks have been built and covered for years, although many never get covered.

Lumber is purchased from many sources. There is a lot of season checking in the oak, and too often sticker marking and sticker rot in the birch and maple. This has been accepted as being more or less inevitable. When lumber was much cheaper they were not too disturbing. Now that prices for lumber are up they should assume a new importance.

Causes of Seasoning Defects

What is the cause of season checking, and why does sticker marking and rot occur? What can we do about it?

In taking down stacks of 6/4 and 8/4 oak which was thoroughly air dry particular attention was paid to the condition of the lumber, layer by layer. Before, taking down a stack was more or less a routine operation without paying any particular attention to the condition of the lumber. This probably is true in most cases after having become so accustomed to season checks and other seasoning defects, that unless there is something outstanding about them the defects are hardly noticed.

As a result, certain features began to assume outstanding importance. There was a concentration of season checking in the upper portion of every stack, wide boards on the edges showed more checking than the same width boards in the centers. This pattern was the same from stack to stack.

In birch and maple the sticker marking and rot was the predominant defect. There was no pattern as found in the oak stacks for season checking. It was noted, however, that wherever either sticker marking or rot was found there was a pronounced water marking above the sticker on the up hill side. There was no definite pattern except that it tended to be more concentrated in the upper part, although marking and rot could be found along the edges from top to bottom.

After having determined the extent and pattern of these defects the next question was that of the primary cause. Because of the higher concentration of season checking in the upper layers and a gradual diminishing as the stack went down, it seemed logical that rain and snow entering the stacks were the cause rather than it being a natural development in drying. The refractory hardwoods will season check when surface drying is uncontrolled and too rapid, but that could not explain satisfactorily the established pattern of checking. Entering rain and snow with the cycles of wetting and drying over weeks and months could be the explanation.

In order to prove this, a roof to adequately protect the stack was needed. At this point the matter of sticker marking and sticker rot came back into the picture, tied to the question of, "Why are stacks sloped from front to back?" Wherever these defects were observed there was a definite water staining.

Why slope the stack in the old familiar way? Does not this slope concentrate the rain and snow? Would not this repeated concentration eventually cause this marking and the rot? Why not slope the stack so that any rain or snow entering would have an opportunity to run off rather than be dammed up? The next step was to prove these ideas.

Stacking Methods

The yard consists, in most part, of foundations built with concrete piers supporting steel rails upon which the lumber is piled (Fig. 1). These were all sloped from front to rear in the accepted manner for hand piling. Several blocks of these were converted to flat sections with no slope. The stacks are 6 feet wide. It was determined to slope these stacks from side to side so

Fig. 1.—Old type of stack with loose board cover which allows wetting of lumber, resulting in season checking, sticker marking and sticker rot.

Fig. 2.—Group of side-sloped, tightly covered stacks. Sides of covers are flush with stack edges. Maximum protection is given to upper parts of stacks.

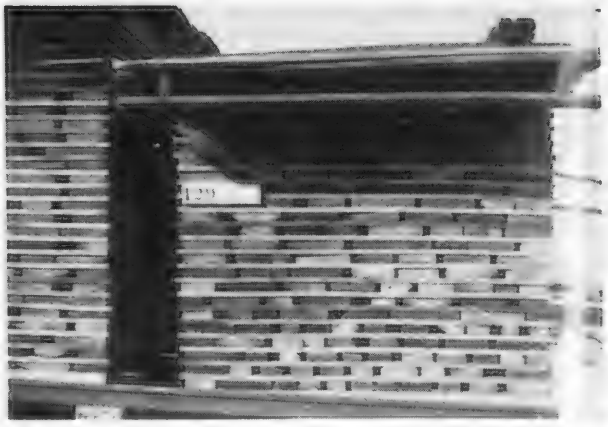

Fig. 3.—Side-sloped stack with water-tight cover. Wedge at base of stack gives side slope. Top cover adequately protects against rain and snow.

that there would be no pooling of water against the stacking sticks and so any rain or snow entering from the sides could drain off at the sides.

To build this slope a 6-foot long wedge was cut for each bottom rail. It was 3 inches at the high end and tapered to nothing at the thin end. The wedges were made from 2-inch stock. In building the stacks on this type slope attention was paid to use the narrow boards on the outer edges. Slightly more care was needed in laying up the edge boards to prevent the stacks curling towards the low sides. The stackers soon became aware of this and adapted their procedure to this (Figs. 2, 3).

A top was devised to give ventilation at the top of the stack and also prevent the rain and snow from entering. A telescoping type of framework was built which could be adapted easily to any length stack.

At this yard the lengths are separated and stacked on a 2-foot basis. One side was 3 inches high, the other 6 inches, being made from 2-inch stock. This is set upon stacking sticks with the sides flush with the stack edges, overhang at the front 18 inches, at the back 24 inches.

A layer of 7-foot boards giving a 6-inch overhang at the sides is put on the framework. Then a lapped layer of water-proof building paper is put down. This then is covered with a second layer of the 7-foot boards, which are then weighted down with heavy timbers or other suitable weights. The sides of the framework coming down flush to the sides of the stack prevent entry of the rain or snow. The overhangs at the front and back protect those points.

Evaluation

Sufficient time has elapsed to evaluate the change. Oak and birch have been stacked in these newer type stacks, both green from the saw and 30 to 60-day dry lumber used. Stacks up for periods of 60 days to nine months have been taken down and carefully checked.

In the oaks there was no pattern of season checking as found previously. There was a small amount of checking in scattered boards especially in that stock which had some drying before receipt at the factory. The lumber received in a green condition was almost free from season checking. What checking was observed was not serious as found before. The lumber was bright and clear throughout. In the birch, which is more liable to sticker rot, there was no indication of rot. Water staining was confined to 2 or 3 inches along the outer edges on the low sides of the stacks. Moisture meter samplings were made at intervals of five layers, a test being made at each edge and the center of the layer.

It was surprising to find in every case that drying within the stack was uniform from top to bottom and from side to side. In the older type of stack the drying progresses from edge to center and from top to bottom so that there is a wide variation of moisture content until the entire stack equalizes at 15 to 18 per cent. Drying time of the side sloped and tightly covered stack is much less than that of the former type. The side sloped stacks have been built on both the reconstructed flat foundations and the conventional front to back sloped foundations. There have been no noticeable differences in the results.

Correspondence with the Forest Products Laboratory and search of various bulletins and reports brought to light that tests of stacks roofed in the former manner at other locations showed essentially the same defects in drying found in these studies. In regard to the side sloping of stacks, the Laboratory reported that while it had no record of this type in the United States, it is in use in some foreign countries, particularly the English speaking. The value of side sloping, particularly in the face of package handling and stacking may be debatable. But there can be no question of the value of either it or the water tight roof when used with hand piled stacks.

Their use has been carried on over a long enough period to show that increase of quality of the lumber has more than paid for the time and material needed to build and roof these stacks. Prevention of rain and snow entering the stacks will pay off in better lumber, less time on the yard, and a more uniform moisture content. Side sloping of the stack permits better drainage both within the stack and from the roof. The combination of these features is well worth development on any yard.

Curing of Oak

A second item in the program is the use of a cure[2] in the drying of 2-in. and thicker oak. Chairs are manufactured in which a fairly large quantity of 2-inch lumber is used in a manner that season checks cause loss of the part. Ten-quarter oak also is used in a chair with backposts sawn from it. Here also, season checks cause loss of the part. In the past this loss has caused the use of much more lumber than the part warranted, especially when air dry lumber was purchased for drying at the kilns. Lumber purchased green and shed dried resulted in fewer season checks but is a slow and space consuming process.

After due investigation a quantity of 10/4 oak green from the saw was purchased and treated with the cure, using the bulk piling method. This lumber was carefully examined the

[2] The Morton Lumber Cure was used in this study for the drying of oak.

time of treatment for checks, splits, and shake, and all such defects marked. After treatment it was stacked for air drying and eventually kiln dried. It again was inspected carefully when being stacked for the kiln. A small amount of additional checking and splitting was observed, some of which could have been missed in the original inspection. Core and shell tests made during the air drying disclosed that drying was definitely progressing from core to shell.

At one point these tests showed a higher moisture content shell than core. This was near the completion of the air drying period. Inspection again was made after kiln drying. Random cuttings were made from the ends, at 41-in. intervals, the rough length of the backpost cut from this stock. Where season checks or splits previously had been found and marked it was found they closed tight without forming the honeycomb type of openings. There was no honeycomb found in any of the cuttings. End splits did not develop beyond their original extent in the green board. The bulk piling method insured complete coverage of the board, lengths being sorted and bulked separately on a 2-foot basis.

Quantities have since been purchased of both 6/4 and 8/4 oak green from the saw. It was treated in the same manner and now is air drying. There also is a rather small quantity of 8/4 and some 2 x 2 x 20 oak squares in the kilns at present. These are being dried with untreated 6/4 of comparative moisture content, both having entered the kiln at a range of 40 to 50 per cent moisture content. This stock is now 15 per cent and all exploratory tests made have not disclosed any damage to the thicker stock or squares.

From experience to date this treatment, when properly applied and handled, will result in much better lumber than is now being obtained by purchase, with the possibility that less time will be needed both on the yard and in the kiln. Samples of the kiln dried 10/4 have been finished with both lacquers and enamels, have had various types of hardware affixed to them and have been placed in both high and low humidity areas to determine if this treatment will result in either sweating of the finish or corrosion of the hardware. After approximately three months there has been no indication of corrosion or sweating.

Bending Procedure

A third point in the program has been developed in the bending room. In the manufacture of chairs many of the parts are bent from solid woods. No laminates are used. The bending of solid wood is very much of a traditional art. There has been very little experimental work done in the laboratories in this country. Most of the bending information is handed down from one bending room man to another, and that usually in the same factory. There are many wide spread ideas on steaming before bending and drying after bending. However it is universally acknowledged that for successful bending, the part to be bent must come from live timber, be free of defects, have a straight grain, and fit the bending pans or straps so there is adequate end pressure.

There the similarity of ideas seems to end. Breakage in the bending room is something to be blamed on wood—too dry, too brash, or too this or that. At the factory operations went on for years on that basis. Breakage was spotty. As designs were changed and the need for more and more bent parts increased the breakage became most serious.

As pressure was put on the bending room for more parts, there would be 50 per cent or over in breakage. The old story that the lumber was causing breakage could not be accepted. Lumber which did not bend successfully today would become "the best we ever had," a few weeks later. Experiments were started with the pressures on the steaming retorts. Pressure was reduced by easy steps from 15 pounds to zero pressure.

Better results were obtained at the low or atmospheric pressure. There still were serious outbreaks of breakage. The bending processes were gone over, and the traditional methods and beliefs either proved or disproved. The focal point was the steaming process, both time and temperature being factors.

In order to eliminate much of the unknown or estimated in the steaming, a temperature controller-recorder was installed on one of the retorts. This made it possible to have absolute control and knowledge of the conditions within the retort for every run. It then became a matter of record that it took a certain definite time to bring the retort and its contents up to temperature. The parts then could be held at a definite temperature for a definite time.

The heat loss during the unloading and bending period also was known. Until this information was known the operator had to be depended upon for this information and sometimes his memory might be faulty. It was now possible to establish definite steaming procedures. This control was effective in reducing breakage to a low percentage. Through continued experimentation it was found it was possible to reduce the retort temperature to 200 degrees F. and eliminate some of the still unaccounted for cross breakage.

This low temperature steaming also aids in reducing drying time after bending. With these controlled conditions damage due to over-steaming is eliminated. Parts have been held with a normal steaming time of one hour for 24 hours with no increase in breakage.

A definite steaming schedule for various species and sizes can be set up and produce uniformly good results. This has resulted in the elimination of the outbreaks of high bending losses. Operations are now on a basis of approximately 2 per cent loss on the oak and 5 per cent on the birch. It is easier to control the supply of oak than that of birch.

All retorts are now equipped with temperature controller-recorders. Having definite knowledge of the time and temperature factors, and being able to control them has meant an increased yield from the same footage.

Summary

Definite savings in lumber have been made through these various changes in procedure. Further benefits can be made by modernizing the thinking all along the line from the lumber producer to the ultimate user.

A Study of Some Factors Affecting the Gap-Filling Properties of Wood Adhesives[1, 2]

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and

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A study was made to determine if factors affecting shrinkage of the adhesive layer can be reflected in the time-thickness function. Four factors were studied. Epoxy exhibited the best behavior; furfuryl modified urea gave slightly higher strengths but with a limitation on maximum thickness and some strength loss; polyvinyl acetate emulsion gave highest over-all strength.

Introduction

IN A PREVIOUS PAPER (1) a method was described which appeared to possess a high degree of sensitivity toward those properties of a wood adhesive which bear on its ability to form a bond under so-called gap-filling conditions. Three distinct elements of a gap-filling condition were recognized: 1) the distance between the joint faces, or thickness of the adhesive film, 2) the actual hydrostatic pressure on the adhesive during the time the bond was forming; and 3) the relative freedom of the two joint faces to move in response to contraction of the adhesive film as hardening progressed. The chief feature of the method was the provision for independently varying and controlling each of these elements with the use of a circularly cut out shim placed in the joint of a cross-lap specimen.

In preliminary studies with this method, it was found that the effect of glue film thickness on strength was sharply dependent upon the time elapsed after a degree of cure had been attained. The strength situation with respect to thickness and time for a furfuryl alcohol modified urea adhesive is depicted in Fig. 3. On the basis of the curves of Fig. 3, it is apparent both time and thickness functions must be included in studies of gap-filling properties. The decline in strength with time after a maximum strength has been reached, accords with the theory that shrinkage stresses in the adhesive layer affect gap-filling properties. The following studies were undertaken to determine whether factors which affect shrinkage of the adhesive layer can be reflected in the time-thickness function.

Four factors were selected for investigation having either a direct or an indirect bearing on the shrinkage effects of the adhesive. These were: 1) amount of walnut shell flour filler 2) type of adhesive, 3) the moisture content of the wood, and 4) the rate of hardening of the adhesive. Of these, the filler content, also was studied in a precisely made dowel joint

The work begun by the late Edward M. Hinken and pursued by him with great zeal and diligence, represents the beginning of what his associates regarded as a brilliant career in the field of Wood Technology. Had his hand remained on the tiller, he would undoubtedly have explored this phase of adhesive action in all of its ramifications. Should this procedure evolve to a method of general applicability, it will mark the efforts of a dedicated, thoroughly human, and deeply loved researcher. (Author's Note).

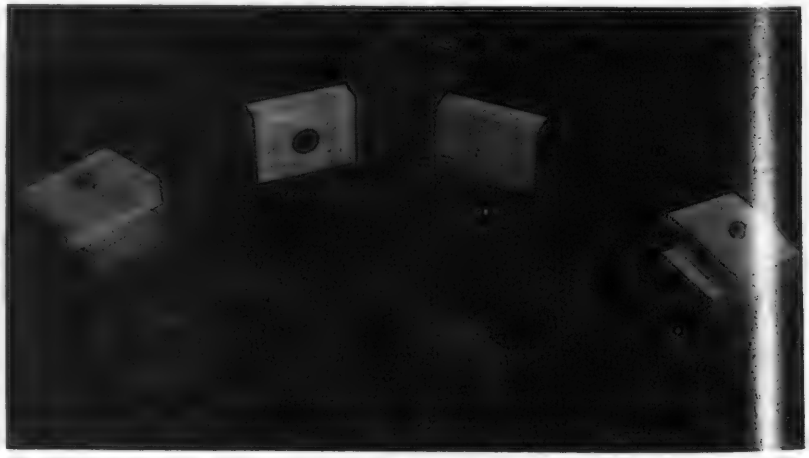

Fig. 1.—The shimmed cross-lap specimen and its component parts.

[1] Presented at Session V, Glues and Gluing, FPRS 10th National Meeting, June 3–7, in Asheville, N. C.

[2] Paper read by Dr. Stephen B. Preston, Chairman, Department of Wood Technology, School of Natural Resources, University of Michigan, Ann Arbor, Mich.

[3] Numbers in parentheses refer to Literature Cited.

The Authors: The late Edward Hinken received a B.S., Forestry degree from the University of Washington and a Master of Wood Technology degree from the University of Michigan. He was completing work towards a Ph.D. at Michigan at the time of his death. He was a wood technologist at the Department of Industrial Research, Washington Institute of Technology, Pullman, Wash., and a member of Xi Sigma Pi, Phi Kappa Phi, Phi Sigma, Sigma Xi and FPRS.

Alan A. Marra received B.S. and M.S. degrees from New York State College of Forestry and Ph.D. from the University of Michigan. He was associated with Engineering Research Corp., Riverdale, Md.; Pluswood, Inc., Oshkosh, Wis.; and Monsanto Chemical Co. before joining the staff of the University of Michigan. He has written several technical articles and is a frequent contributor to the JOURNAL. A charter member of FPRS, Marra is past chairman of the Glues and Gluing Division.

to provide a closer tie between the specimen used and a common type of joint where gap conditions sometimes prevail.

The specimens for these studies were made and tested as described in a previous report (1) using sugar maple wood, closely selected for straightness of grain, and narrow specific gravity range. All bonding was done with a pressure on the adhesive of 10 psi, experimentally determined to be adequate for assuring complete contact of adhesive with the joint surfaces, and yet avoid too much penetration of the adhesive into the wood. While different adhesives vary in pressure requirements, the ones used in the following experiments were assumed, on the basis of their consistency, to fall in the same class. In all experiments, relative humidity and temperature conditions were kept constant throughout the period of the observations.

The Effect of Walnut Shell Flour

The action of walnut shell flour was expected to be due to its relative inertness. The proportion of walnut shell flour therefore should affect the total amount of shrinkage which the adhesive film can undergo during cure. In order to provide the greatest opportunity for this factor to show its effects, a neat powdered urea resin was selected as the adhesive base. Four levels of filler content were established, 0, 10, 20, and 30 per cent of the resin. The formulations were adjusted to give the same consistency and gel time (28 minutes at 120° F.) Each of the four filler variations were cast in joints varying in thickness .005, .010, .020 and .040 inches. Each filler-thickness combination was then tested at intervals of one, two, three and four weeks, during which time the specimens were maintained at their original E.M.C. condition of 8 per cent and 75° F. The entire experiment was repeated once to provide for the operation and accounting of chance factors which might influence the interpretation of the results.

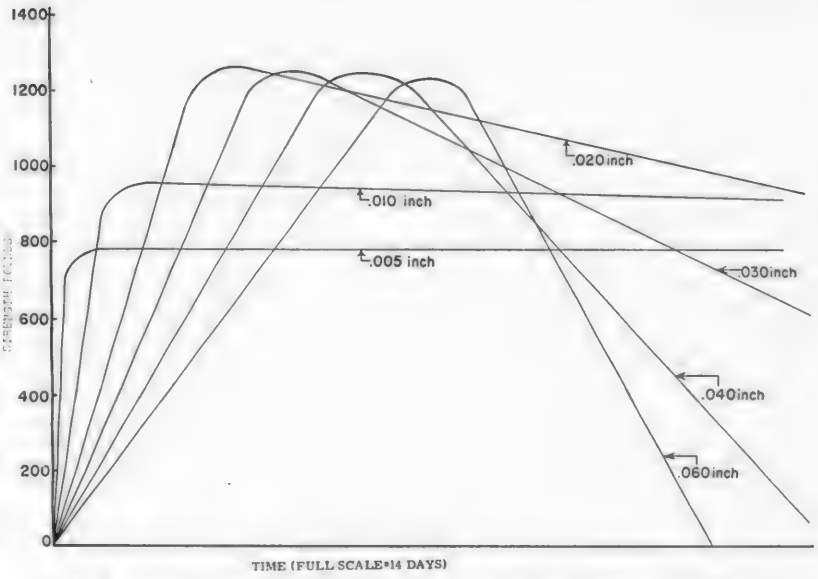

Fig. 3.—Typical response of a modified urea formaldehyde adhesive at different joint thicknesses and elapsed times before testing.

The results given in Table I show a rather marked effect of filler on the over-all strength. Although the two upper levels of thickness, .020 and .040 inch did not contribute to the trends observed, since they produced zero strength due to the long time intervals chosen, a clear relationship of filler with respect to thickness and time emerged. As can be seen from the plot of the data in Fig. 4, the effect of filler differed with each thickness. The strength of the .005-inch thick joint was not greatly affected

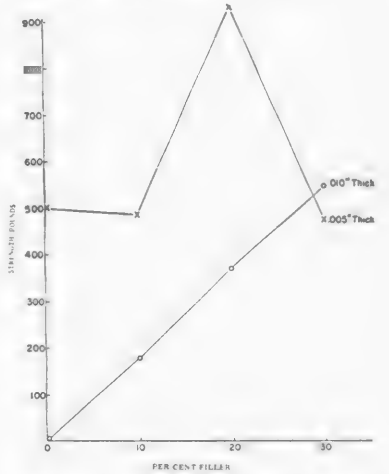

Fig. 4.—The effect of walnut shell flour filler upon strength of a urec-formaldehyde bond at two film thicknesses.

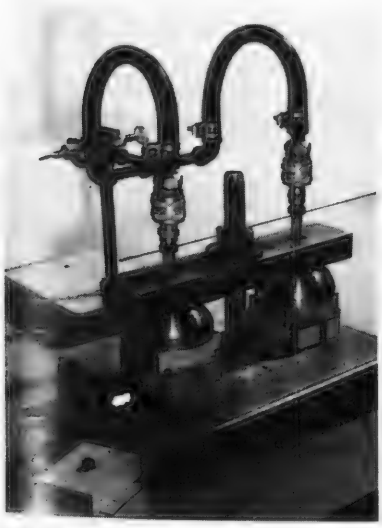

Fig. 2.—Clamping device for clamping the shimmed cross-lap specimen. Bonding pressure is introduced directly to the glue line through hoses and connecting nipples.

Table 1.—THE EFFECT OF WALNUT SHELL FLOUR FILLER UPON STRENGTH WITH RESPECT TO TIME AND THICKNESS WITH A UREA RESIN ADHESIVE IN THE SHIMMED CROSS-LAP SPECIMEN

Time Weeks	Shim Thickness Inches	Per cent Filler: 0	10	20	30	Totals
		Joint strength pounds				
1	.005	632	715	872	667	2886
	.010	0	153	689	921	1763
	.020	0	0	0	0	0
	.040	0	0	0	0	0
2	.005	401	338	852	561	2152
	.010	0	118	122	898	1138
	.020	0	0	0	0	0
	.040	0	0	0	0	0
3	.005	675	565	731	360	2331
	.010	0	295	395	275	965
	.020	0	0	0	0	0
	.040	0	0	0	0	0
4	.005	298	335	433	323	1389
	.010	0	198	420	130	748
	.020	0	0	0	0	0
	.040	0	0	0	0	0
Sub-totals	.005	2006	1953	2888	1911	
Sub-totals	.010	0	764	1626	2224	
Totals		2006	2717	4493	4135	

except for a sharp increase at 20 per cent filler. On the other hand, filler appeared to be solely responsible for all the strength developed by the .010-inch thick specimen, since no strength occurred at this thickness until some filler was added. Fig. 5 however, shows that the benefits of walnut shell flour, are only temporary since the inevitable decline of strength with time occurred at all filler levels. The rate of decline more-over, increased with increasing filler content and it is evident that extra-polation of time would bring each filler level to zero strength. The slight indication of an optimum filler content in the order of 20 per cent requires further verification.

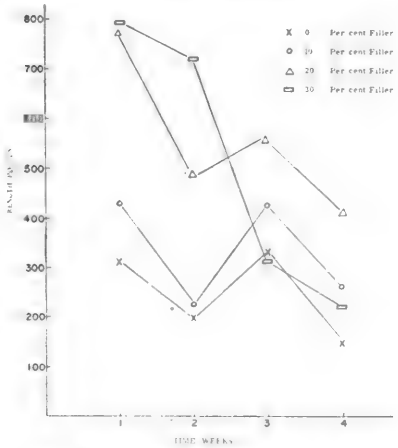

Fig. 5.—Rate of strength decline as affected by varying percentages of walnut shell flour filler in a straight urea-formaldehyde adhesive under gap-filling conditions.

The improvement in temporary strength with increasing walnut shell flour is not easily explained. It cannot be ascribed to the normal action of fillers in retarding penetration and preventing starved joints. Starved joints are not a factor in the present situation since ample adhesive is always present as a "head" in the nipple leading to the center of the specimen. The action therefore may actually be one of benefit to the film itself. This may be, as has been observed by others, that the inclusion of small inert particles in a substance under stress serves to distribute crazing strains and thus delay the accumulation of severe internal stress at a particular point or line.

It would appear that the addition of walnut shell flour to a urea adhesive will not result in better performance under gap-filling conditions if strength decline with time is taken as a criterion. Of equal importance is the indication that small differences in the adhesive imparted by the addition of an inert material may be reflected by the shimmed cross-lap specimen.

Comparison With a Dowel Specimen

The development of a new specimen intended to measure primarily adhesive properties, inevitably raises a question as to how the values obtained relate to an actual situation where thick glue lines may occur. A dowel joint is such a situation. Variability in the relative size of the dowel and the hole is a common source of concern for the strength of the joint. A dowel-type specimen was therefore considered a logical point of comparison for evaluating the response of the shimmed cross-lap specimen.

The dowel joint specimen used in this study was specially devised to control the gap and the centering of the dowel in the hole, Fig. 6. A spur bit used to drill the hole, provided a means for positioning a small pin in the exact center of the dowel. In order to insure accurate mating of the two members of the joint, each was appropriately notched to make them self-locating. The adhesive was applied both to the hole and the dowel. Wax on the contacting surfaces of the blocks prevented squeeze-out from forming a bond. The gap in each case was determined by cutting the dowel to a precise diameter on a metal turning lathe. All dowel holes were constant in diameter.

As a basis for the comparison of the shim specimen with the dowel specimen, it was decided to observe

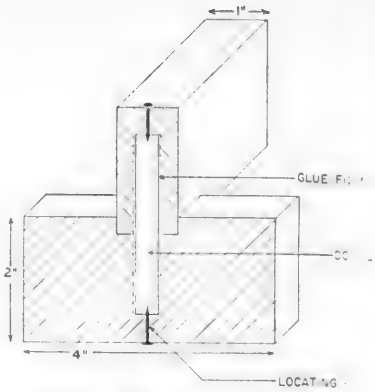

Fig. 6.—Cut-away drawing of the dowel specimen.

the response of each to changes in filler content since this factor was shown in the previous experiment to produce distinct effects. A shorter time interval, and a urea adhesive modified by the addition of furfuryl alcohol were used in order to gain additional information at the upper glue line thicknesses. The following factors comprised the matrix for interactions:

1. Specimens—dowel and shim
2. Filler content—0, 15 and 30 per cent on the basis of resin solids.
3. Adhesive Film Thickness—.005, .010, 020 and .034 inches.
4. Cure time—1, 2, 3, 5, 7, and 9 days.
5. Adhesive—urea resin modified with furfuryl alcohol and catalized to gel in 10 minutes at 120° F.
6. Replications—one.
7. Wood moisture content—8 per cent, constant.

The data given in Table II show a decided difference in levels of strength shown by the two specimens. The response however is similar. As shown by the plots in Figs. 7, 8, and 9. the dowel specimen loses strength as fast as the shim specimen when either time or thickness are increased.

Of particular note is the higher strength of the dowel specimen at the

Table 2.—COMPARISON OF THE SHIMMED CROSS-LAP SPECIMEN WITH A DOWEL SPECIMEN ON THE BASIS OF RESPONSE TO WALNUT SHELL FLOUR FILLER IN A UREA RESIN MODIFIED WITH FURFURYL ALCOHOL

		Shim Thickness Inches											
		.005			.010			.020			.034		
		Per cent Walnut Shell Flour											
Specimen	Time Days	0	15	30	0	15	30	0	15	30	0	15	
		Pounds Joint Strength											
Dowel	1	1730	1540	1705	1365	1555	1530	1385	1365	1375	935	925	1
	2	1330	1630	1555	1340	1390	1645	1125	1365	1290	750	935	1
	3	1465	1700	1540	1125	1290	1350	790	1125	1280	650	810	
	5	1110	1310	1475	1005	1320	1385	785	975	1345	640	765	
	7	1110	1670	1420	1230	1325	1370	945	1020	1245	585	720	
	9	1320	1550	1295	1180	1070	1265	520	945	1240	725	820	
Shimmed Cross-Lap	1	1080	860	990	960	1055	900	825	920	1130	0	1185	1
	2	1035	930	1040	1055	1165	845	155	575	995	0	0	
	3	1100	1150	950	1080	965	1045	0	0	675	0	0	
	5	730	1070	865	870	900	880	0	0	100	0	0	
	7	740	665	970	850	960	1000	0	0	45	0	0	
	9	630	760	820	480	865	990	0	0	0	0	0	

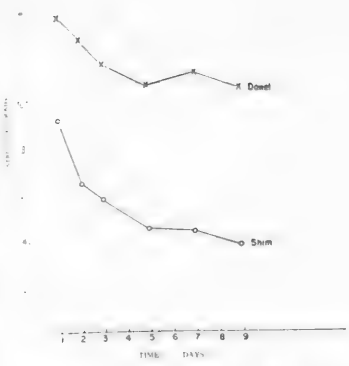

Fig. 7.—Comparison of the shim specimen with the dowel specimen on the basis of rate of strength loss.

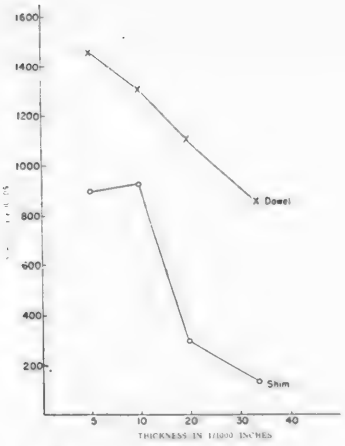

Fig. 8.—Comparison of the shim specimen with the dowel specimen on the basis of gap tolerance.

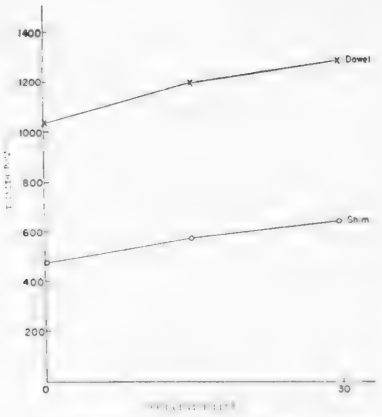

Fig. 9.—Comparison of the shim specimen with the dowel specimen on the basis of response to walnut shell flour filler.

greater thicknesses. The contracting stresses set up by the curing adhesive, may be as effective in causing strength loss in a dowel joint as they are in the shim specimen, but the shim specimen provides a more severe test of the adhesive properties and hence may be considered accelerative in effect. The fact that the comparison is based on tension vs. shear may have a bearing here, since the joint can be considered prestressed in tension, but not necessarily prestressed in shear.

Two important implications emerge from this study: one, that the cross-lap specimen with incorporated circular shims appears to closely reflect some condition affecting bond strength under gap-filling conditions; and two, that the reflection is on the side of maximum severity, and would therefore provide conservative interpretations. It should be noted however that only imposed effects were here reflected. The scope and period of observation were extremely limited in this experiment. There is yet no confirmation that the performance of an actual dowel joint would also be proportionately affected over a longer time scale.

A Comparison of Adhesive Types

Adhesives vary widely in rheological (flow) properties before, during, and after curing. Many of these properties result from the basic molecular structure of the adhesive; some result from additives which are incorporated as modifiers; and some depend on the solvents and catalyst systems used to carry and cure the adhesive mass. As far as gap-filling action is concerned, the degree to which these properties affect bond formation at low pressures, and affect internal stress in the cured adhesive film, would appear to be the important considerations. This experiment was executed to observe the response of the shimmed cross-lap specimen to adhesives which differ in these respects.

Three adhesives were selected which were believed to differ as much as possible. These were 1) an epoxy, a brittle adhesive with a high modulus of elasticity which cures by chemical reaction without solvent, 2) a furfuryl alcohol modified urea also of high modulus, curing by chemical reaction in the presence of both volatile and non-volatile solvents, and 3) a polyvinyl acetate emulsion, of comparatively low modulus hardening by loss of solvent to the wood. These were expected to reflect the adhesive effects of high modulus with low shrinkage, high modulus with intermediate shrinkage and low modulus with high shrinkage, respectively.

The three adhesives were cast in joints of four thicknesses .005, .010, .020, and .040 inches, and tested at four intervals of time—one, two, three and four weeks. Table III gives the results. They are plotted in Figs. 10 and 11. As can be seen, the polyvinyl

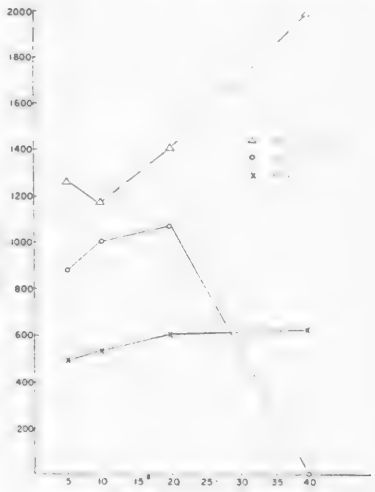

Fig. 10.—Comparison of three adhesives on the basis of film thickness tolerance.

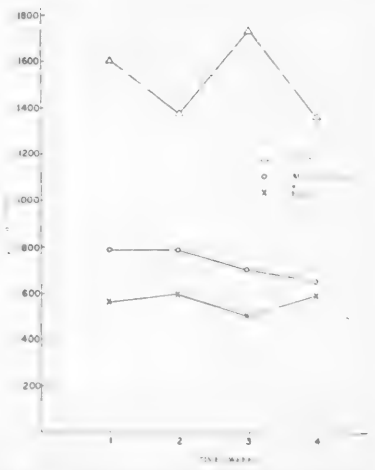

Fig. 11.—Comparison of three adhesives on the basis of loss of joint strength with time.

Table 3.—COMPARISON OF AN EPOXY RESIN, A FURFURYL ALCOHOL MODIFIED UREA, AND A POLYVINYL ACETATE ON THE BASIS OF REACTION TO THE TIME-THICKNESS FUNCTION

Time	Weeks	Adhesive Type	Shim Thickness Inches .005	.010	.020	.040
			Pounds Joint Strength			
1		Epoxy	394	550	695	635
		Mod. Urea	925	1140	1130	0
		PVA	1680	1265	1480	2065
2		Epoxy	600	605	590	605
		Mod. Urea	950	1160	1080	0
		PVA	1080	1155	1240	2080
3		Epoxy	460	460	540	580
		Mod. Urea	795	1010	1055	0
		PVA	1295	1200	1416	2085
4		Epoxy	585	545	610	710
		Mod. Urea	890	740	1050	0
		PVA	1050	1105	1560	1800

actetate adhesive has markedly greater strength at all film thicknesses, increasing in fact with thickness, and appeared able to maintain that strength with but small loss over the period of observation, four weeks. The epoxy resin showed a similar trend except at a far lower strength level. On the other hand, the modified urea displayed a sharp end-point on thickness tolerance between .020 and .040 inch, with a slight loss of strength with time.

These results are quite definitive but need to be viewed critically, more critically than is possible with the information at hand. For example, the performance of the polyvinyl adhesive does not appear to be completely reflected. The response of this adhesive is contrary to observations made with other adhesives and suggests the possibility that ultimate hardening is affected by film thickness due perhaps to the greater total amount of solvent involved. Whether or not longer times will show the polyvinyl to be similar to the modified urea in Fig. 3 except with an expanded time scale remains to be verified. It would appear that the inherent plasticity of this type of adhesive might affect the degree of stress due to shrinkage strain, and thus result in a new family of curves characteristic for its type.

The action of the epoxy resin is explainable on the basis of shrinkage theory. Since very little shrinkage occurs as this resin cures, the strength it is able to achieve is independent of thickness within the limits studied. Moreover, very little stress is induced with time which can subtract from the strength of the bond. Despite the comparatively low strength observed for the epoxy adhesive, it would appear that it possesses the time-thickness behavior necessary for gap-filling situations.

Insofar as the shrinkage of a urea adhesive can be controlled by the use of non-volatile solvents, its behavior might be expected to approach that of an epoxy. The particular modified urea used in this experiment appears to have nearly accomplished that objective. Except for different levels of strength and the failure of the urea at .040 thickness, the urea appears similar to the epoxy, within the limits of the experiment.

A comparison of the different ureas used in the several experiments is tempting although not very conclusive owing to lack of coordination with time. The urea adhesives were either unmodified, or modified with furfuryl alcohol, the latter type being from two different manufacturers. From cursory analysis of preceding graphs it would appear that considerable improvement in thickness and time tolerance can be achieved by proper manipulation of additives.

The Relation of Wood Moisture Content and Rate of Cure to Gap-Filling Action

The assumption had been made that loss of joint strength under gap-filling conditions is due to stresses set up in the adhesive film as a result of shrinkage accompanying solvent loss. If this is correct it should follow that the more solvent lost while the adhesive is relatively plastic, that is before curing has progressed to a point of creating elastic properties, the less should be the subsequent loss of strength with either time or thickness.

To test this hypothesis and also to further illustrate the responsiveness of the shimmed cross-lap specimen, two factors were selected for study which affect the amount of solvent present in a chemically hardened film: moisture content of the wood and rate of cure of the adhesive. It was reasoned that the lower the wood moisture content the more water it would absorb from the adhesive before it hardened. Likewise, the slower the adhesive cured the more water should be lost to the wood before the hardened state developed. Either condition should result in an effect upon the shrinkage of the hardened adhesive film, and it was expected that optimal, and perhaps interacting effects might be observed.

Different levels of these factors could produce effects on joint strength not related to shrinkage but to some other reaction such as cohesive strength of the film. This would of course, preclude complete separation of some of the precise effects desired. However, since shrinkage effects are observable as a rate, as well as an equilibrium function, a major isolation of effects should be possible by considering the rate of change of strength with time and thickness.

The following variables were included in a closely controlled factorial experiment of 192 combinations.

1) Wood moisture content—8, 12 and 16 per cent.
2) Amount of catlyst—0.5, 1.0 and 1.5 per cent giving a working life at 70° F. of six, four and two hours respectively.
3) Adhesive film thickness—.005, .010, .020 and .034 inches
4) Cure time—one, three five, and seven days
5) Replications—one

A single adhesive was used, a urea with 15 per cent walnut shell flour filler, modified with the addition of furfuryl alcohol.

The data are given in Table IV, and although they cannot be completely represented by two-dimensional graphs, the more important comparisons are illustrated in Figs. 12, 13, 14, 15, and 16. In general it would appear that the higher wood moisture contents and slower rates of cure result in better film thickness tolerance, but no change in rate of strength decline with time.

The observed effect of wood moisture content, Figs. 12 and 13, is not in accord with the anticipated results.

Table 4.—EFFECTS OF RATE OF CURE AND WOOD MOISTURE CONTENT ON THE TIME-THICKNESS FUNCTION WITH A FURFURYL ALCOHOL MODIFIED UREA IN THE SHIMMED CROSS-LAP SPECIMEN

		Shim Thickness Inches										
		.005			.010			.020			.034	
		Catalyst Per cent										
M. C. %	Time Days	0.5	1.0	1.5	0.5	1.0	1.5	0.5	1.0	1.5	0.5	1.0
		Pounds Joint Strength										
4	1	950	1020	1100	1070	1225	815	1290	1200	955	1285	1210
	3	970	1030	1115	1175	985	765	1225	0	0	0	0
	5	960	1255	1080	1155	1000	300	0	0	0	0	0
	7	1170	1070	1090	1160	930	390	0	0	0	0	0
8	1	1200	1190	1100	1260	1235	1245	1110	1270	770	1360	1240
	3	1210	1165	1015	1220	1090	1025	1310	600	0	1390	0
	5	1155	1300	1165	1415	1055	920	1230	0	0	0	0
	7	1085	1185	1200	1190	1040	860	1430	0	0	0	0
12	1	860	935	1050	1060	1105	960	855	975	1030	1040	925
	3	915	900	745	910	1090	900	1230	930	0	1375	980
	5	1025	935	725	1175	960	935	905	905	0	1280	0
	7	1030	985	930	1125	1075	900	755	125	0	1400	0
16	1	1060	960	775	1155	900	820	1095	885	890	1060	540
	3	955	915	800	1050	840	890	995	905	0	1020	0
	5	1100	880	860	1130	820	825	1165	0	0	1090	0
	7	940	890	875	1025	955	800	1200	0	0	945	0

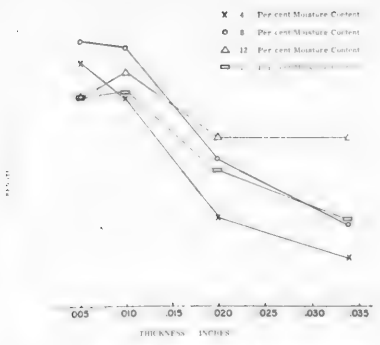

Fig. 12.—The effect of wood moisture content upon film thickness tolerance with a furfuryl alcohol modified urea.

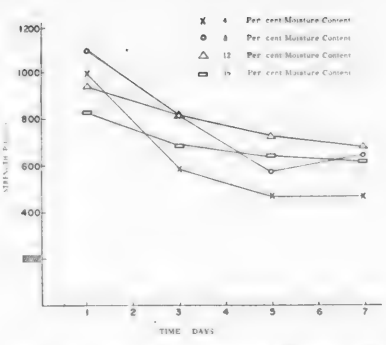

Fig. 13.—The effect of wood moisture content upon decline of joint strength with a furfuryl alcohol modified urea.

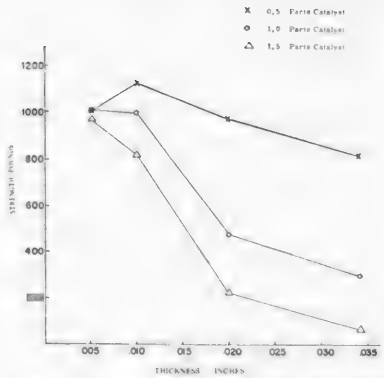

Fig. 14.—The effect of rate of cure upon joint strength at various shim thicknesses with a furfuryl alcohol modified urea.

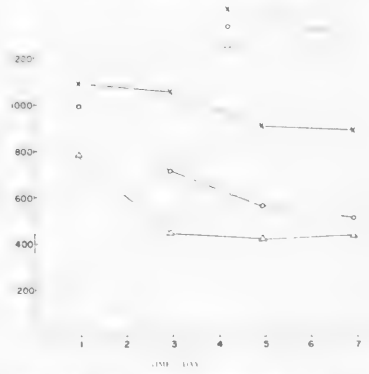

Fig. 15.—The effect of rate of cure upon decline of joint strength with a furfuryl alcohol modified urea.

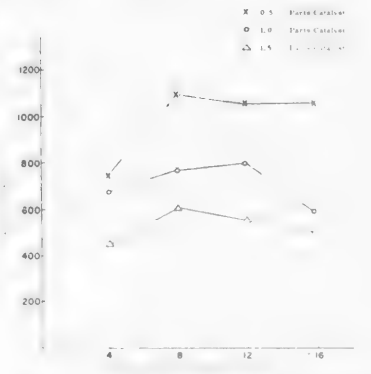

Fig. 16.—The effect of rate of cure upon joint strength at different wood moisture contents with a furfuryl alcohol modified urea.

It might therefore be presumed that rate of water absorption from the adhesive before completion of the curing action is not the only factor. Additional factors must be considered and these may include the possibility that loss of solvent also affects the hardening process; that shrinkage effects may accompany, as well as follow, the hardening action; or that the amount of solvent loss, rather than the rate, is the deciding factor. The latter alternative must further consider the possibility of an optimum in view of a trend for 12 per cent moisture content wood to favor gap-filling action more than the others.

The effect of rate of cure on the time-thickness function is more definite, with a clear distinction between catalyst levels, Figs. 14 and 15. The slower rate of cure produced good bonds at the greatest film thickness, and moreover a large portion of that strength was maintained throughout the time interval of the test. This would tend to support the theory with respect to solvent loss before hardening. Again however, additional factors may be in operation, such as the physical nature of the cured film as the result of changes in the rate of the curing reaction.

The generalizations with respect to the main effects of moisture content and rate of cure are statistically significant. Their plotted effects however, do not depict the entire situation due to the fact that some factors influence the action of others. In graphically showing the relationship between any two variables, the other two were necessarily pooled into the average for each point. When these other two affect the variables being compared differently at each level, the complete relationship of the factors is obscured. A study of the data, therefore, must take into consideration the interactions between factors.

As indicated in the statistical summary, Table V, all interactions involving thickness of the glue line are significant to a high degree, while those involving time are not, except when acting upon thickness. This means that moisture content of the wood, the rate of cure of the adhesive, and time, all affect the strength observed, but the net effect of each depends upon the gap thickness. Referring again to Table IV, these differential effects can be seen to be most strongly manifest at the greater thicknesses, and considerably less pronounced or absent at the smaller thicknesses.

The thickness interactions are particularly important in evaluating adhesives since they imply that maximum distinction can be achieved with the upper gap thicknesses. For example, the effect of rate of cure is much more obvious at a thickness of .035 inch than at .005 inch, Fig. 14. Similarly the effect of moisture content is greater at .035 inch than at .005 inch.

Table 5.—ANALYSIS OF VARIANCE SUMMARY ON VALUES IN TABLE 4

		Sum Squares	df	Estimated Variance	F	P
Moisture content	i	1,030,651	3	343,550	5.23	<.01
Time	j	3,974,662	3	1,324,887	20.17	<.001
Catalyst	K	7,226,928	2	3,613,464	55.01	<.001
Thickness	l	13,848,157	3	4,616,052	70.27	<.001
	ij	632,022	9	70,225	1.07	NS
	ik	675,155	6	112,526	1.71	NS
	il	1,524,477	9	169,386	2.58	<.01
	jk	741,444	6	123,574	1.88	NS
	jk	3,203,216	9	355,913	5.42	<.001
	kl	3,180,586	6	530,098	8.07	<.001
	ijk	1,160,131	18	64,452	1.14	NS
	ijl	1,281,646	27	47,468	.84	NS
	ikl	1,726,314	18	95,906	1.70	NS
	jkl	1,654,788	18	91,933	1.63	NS
	ijkl	3,045,354	54	56,395		
	ined error	8,868,233	191 135	65,691		

The fact that neither moisture content nor rate of cure showed any tendency to interact with time indicates that one of the main effects of these factors is merely to change the level of strength, and not to change the rate of strength decline with time. As a practical matter therefore, it would seem that despite greater strength at higher gap thicknesses, the true gap filling properties based upon rate of strength loss, have not been changed as a result of varying the rate of cure or the wood moisture content.

Another important interaction which did not materialize was the effect of rate of cure upon the wood moisture content. The relationship is shown in Fig. 16. Since both these factors were believed to affect the ultimate shrinkage of the cured adhesive, some compounding of their effects should have occurred. However, the effect of changing the rate of cure was solely a corresponding change in the strength at each moisture content level. No significant divergence is apparent, and some canceling action, rather than compounding, may be postulated.

The above results show a complexity in the factors affecting gap-filling action which is not readily explainable. It would appear however that favorable manipulation of the factors affecting the hardening action may lead to some improvements.

Summary

Under the assumption that one of the main considerations in evaluating adhesives for gap-filling properties relates to the shrinkage of the adhesive upon hardening, a number of factors were studied to determine whether the shimmed cross-lap specimen would respond to different manifestations of shrinkage.

In most cases definite responses were observed. Walnut shell flour filler, up to 30 per cent on the weight of the resin, improved the thickness tolerance of a straight urea adhesive but not the rate of strength decline with time. It was found that the response to addition of walnut shell flour in a furfuryl alcohol modified urea was the same in a dowel type joint as in the shimmed cross-lap specimen. The time-thickness reaction of a furfuryl alcohol modified urea to changes in wood moisture content and rate of cure indicated that higher moisture contents and slower rates of cure are conducive in some degree to improved gap-filling action. In comparing three chemically different adhesives it was deduced that an epoxy exhibited the best behavior under increasing time and film thicknesses; a furfuryl modified urea gave slightly higher strengths but with a definite limitation on maximum thickness between .020 and .040 inches and with some strength loss with time; and a polyvinyl acetate emulsion gave the highest over-all strength. In all cases however the period of observation was so short that the responses must be considered incomplete and generalizations are not warranted.

The interpretation of these data should also be tempered with the realization that knowledge is still largely lacking on the relationship of test values to performance in actual constructions. In this connection, it should be noted that many of the effects of the various factors studied tend to become less pronounced at the lower film thicknesses. The lower film thicknesses are nearer practicality and hence it might be inferred that the effects observed are not as important under normal working situations. Considered in the light of an accelerated test however, the results take on increased significance since the object is to make conditions more severe than normal in order to reveal distinguishing characteristics sooner than normal.

The foregoing data were therefore presented without detailed elaboration in the hope that they would be more closely studied by others who might have greater experience in the composition of adhesives and the mechanisms of their reactions. Since the method appears to have some sensitivity to factors presumed to be important in gap-filling situations, it is felt that theories can be tested as they arise and stepwise progress toward better gap-filling properties can be made.

Improvements in the test procedure toward greater simplifications and reductions in variability are needed. Many ideas will no doubt occur as further experience is gained. At the present time it appears probable that the manner of inserting the nipple for the application of bonding pressure can be made easier. Likewise the number of shim thicknesses needed to characterize an adhesive may be decreased.

While the time-thickness function appears to be useful for observing the behavior of adhesives under gap-filling situations, it does not provide quantitative results such that treatments could be compared on a single numerical scale. However, a means of extracting a value which would represent the gap-filling property of a formulation may be possible under certain, as yet unproven assumptions. If thickness of the gap be considered an instrument for magnifying a difference between adhesives, the time element may be viewed as a means of modulating those differences to permit appraisal as a rate function. Means for determining at what maximum thickness rate of strength decline remains zero would appear to permit the calculation of a "critical glue line thickness" for characterizing the gap-filling property of wood adhesives. This would have the additional advantage of avoiding the use of absolute strength as a criterion of the effects being observed. A study of this approach is in progress.

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Dimensional Stabilization of Wood Part IV. Allylation[2]

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Allylation may be commercially valuable as a method of permanently increasing the dimensional stability of wood. It was found to be superior to butylation. The treatment is simple, and the treated wood is stable in water.

Theoretical and Historical

RECENT INTEREST has been focused on the use of the allyl group as a component of protective coatings (4), in which the allyl group has been joined to starch by an ether linkage. Other allyl carbohydrates have been prepared, including allyl cellulose, formed from alpha cellulose and from native cellulose (1, 5, 7). These all use sodium hydroxide as the alkali in the etherification process. In more recent work Kenega et als. (2, 3) used pyridine as catalyst, but found that temporary dimensional stability only was imparted to the wood by the formation of a leachable allyl pyridine chloride polymer laid down within the wood. No etherification occured.

The replacement of the hydroxyl groups of cellulose and lignin with the allyl group could improve dimensional stability for two reasons: (a) the introduction of a less hygroscopic allyl group, and (b) the unsaturated allyl group could be expected to form cross-linked polymers within the cell-wall.

Attempts were therefore made to find a catalyst which would bring about etherification and yet would not adversely affect the strength or appearance of the wood. After preliminary experiments using such acid catalysts as zinc chloride, boron trifluoride, and anhydrous aluminum chloride, the last one was singled out for more extensive study. Eventually it was shown that aluminum chloride as used herein had no catalytic effect other than possibly holding the wood in a semi-swollen state, thereby permitting better penetration by the alkylating agent. An allylation treatment requiring no catalyst, and another treatment using higher temperatures, were then tried.

Experimental

A. Allylation in Presence of Catalyst

a. Depositing the Catalyst in the Wood: The following procedure was devised to deposit anhydrous aluminum chloride in wood: the catalyst was dissolved in water-free acetone cooled to −10° C. When the desired quantity had been dissolved, oven-dry balsam fir wafers were soaked in the solution for 18 hours, the solution being kept below 0° C. at all times. They were then dried of excess acetone at 100° C. By this procedure the aluminum chloride was made to penetrate to the center of cylindrical blocks 1.5 inch in the fiber direction and 1.5 inch in diameter.

b. General Procedure for Allylation: The catalyst-treated samples were soaked in allyl chloride for 18 hours, then were placed in a large beaker, covered with a watchglass, and placed in an oven at 100° C. After this heating period, the samples were removed from the beaker and dried for three hours in the usual manner. When cooled, they were weighed and measured.

B. Allylation Under Pressure

A series of wafers (1.5 inch in diameter, 1.0 inch long) of yellow birch (Betula lutea Michx.) having no catalyst pretreatment, was soaked in allyl chloride for four hours and then heated in an autoclave under pressure for various lengths of time at temperatures shown in Table 1. One sample (M43–8) was evacuated of air before being soaked. After treatment the wafers were dried at 100° C. for 24 hours. They were then weighed and measured, and soak-tested for anti-shrink efficiencies.

C. Allylation Without Catalyst at Ordinary Pressure

Wafers of balsam fir similar to those used in (B) were evacuated of air for 30 minutes. Allyl chloride was run in and the samples soaked for two hours. They were then placed in a covered bottle and heated for 18 hours at 100° C. Some samples received this treatment once, twice, thrice, and four times. They were then dried for two hours at 100° C., cooled, weighed, and measured. Table 2 shows the increases in weight and in tangential dimensions of the wafers upon treatment.

D. Humidity Studies

The mechanism of dimensional stabilization by the above allylation treatments was determined by studying the hygroscopic properties of the woods.

Table 1.—EFFECT OF THE TEMPERATURE AND HEATING TIME UPON SOME OF THE PROPERTIES OF YELLOW BIRCH WAFERS ALLYLATED UNDER PRESSURE

Sample No.	Temp. °C.	Time Hours	Weight Change %	Tangential Swell %	Reduction in Water Absorptivity %	Anti-shrink Efficiency %
M43 C			Control			
M43-2	69	6½	2.2	0	42.0	22.2
M43-3	69	18½	1.5	0	33.7	26.3
M43-4	120	6½	1.1	0.14	35.9	29.4
M43-5	120	18½	−1.3	1.03	38.6	28.3
M43-6	200	6½	−20.8	0.80	58.0	53.1
M43-7	200	21	−21.9	0.56	60.3	48.9
M43-8	140	47	−11.8	5.26	78.3	89.1

[2] This paper constitutes part of a thesis submitted by D. F. Arseneau in partial fulfillment of the degree of D.Sc. in Chemistry, Graduate School, Laval University, May, 1955. Financial assistance was given by the Shell Oil Co. and the Quebec Scientific Research Bureau.

This is the fourth in a series of five papers. Part III appeared in the June, July and August issues.

The paper was prepared while Dr. Arseneau was a graduate student at Laval. He now is on the staff of the Department of Chemistry, Xavier University College, Sydney, N. S., Canada.

Numbers in parentheses refer to Literature

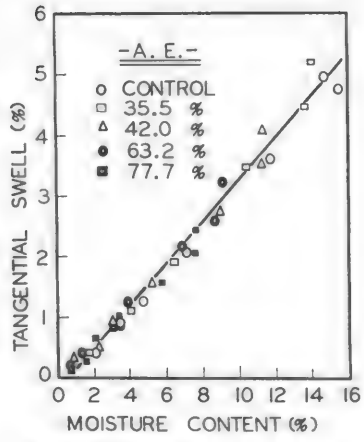

Fig. 1.—Relation between moisture content and tangential swell for allylated balsam fir wafers of various antishrink efficiencies (A.E.).

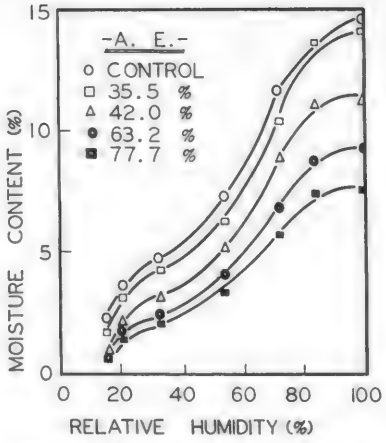

Fig. 2.—Relation between relative humidity and moisture content for allylated balsam fir wafers of various antishrink efficiencies (A.E.).

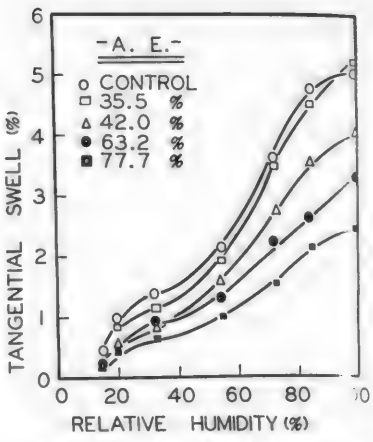

Fig. 3.—The per cent tangential swell of allylated balsam fir wafers resulting from relative humidity changes (A. E.: antishrink efficiency).

Figs. 1, 2 and 3 show the results of this work. For want of a better means of identifying the different allylated wood samples, they are identified in these figures by their antishrink efficienices at apparent swelling equilibrium; 'apparent' in that the samples stopped swelling. These figures however suggest that the A. E. of water-soaked samples may be higher than the A. E. of the same samples subjected to water vapor.

Discussion

The antiswelling property imparted to wood by allylation is not a bulking effect as was the case of butylation treatments. Two things illustrate this. First, the tangential dimensions of the samples remain practically unchanged upon treatment as shown in Table 2. The bulking theory presupposes at least a partially swollen condition of the treated wood. Without this swollen condition there can be no bulking. Secondly, throughout the entire range of moisture contents studied (Fig. 1), the swellings at a given moisture content are the same for all allylated samples. Thus no matter what degree of allylation, similar moisture contents result in the same tangential swell. If the antiswell property were to be attributed to bulking, samples of each degree of allylation would possess moisture content-tangential swell curves of different maxima (see Fig. 8, Part III: Butylation).

That the antiswelling property of allylated wood results from reduced hygroscopicity is evident from Fig. 2.

Table 2.—THE EFFECTS OF THE NUMBER OF ALLYLATION TREATMENTS (WITHOUT CATALYST) UPON TWO PROPERTIES OF BALSAM FIR WAFERS

Number of Treatments	1	2	3	4
Upon Treatment:				
Weight Increase %	9.8	12.4	15.5	17.4
Tangential Swell %	0.14	0.07	0.14	0.07

Over the entire humidity range, allylated samples display decreased hygroscopicity and since hygroscopicity determines moisture content, which in turn regulates swelling, the great reduction in tangential swelling of allylated wood (as much as 88 per cent) is to be attributed to reduced hygroscopicity. Fig. 3 shows the actual tangential swelling of allylated samples over the entire humidity range.

The above suggests that dimensional stability results partially from the deposition of an hydrophobic layer of allyl chloride polymer within the wood which reduces the rates of swelling and shrinking. This was further supported by the fact that a 24-hour soak in acetone followed by drying and soaktesting, resulted in reduced antishrink efficiencies. Upon evaporation, the acetone yielded a brown gummy substance.

By varying the amount used in the pretreatment, aluminum chloride catalyst was found to have very little effect upon antishrink efficiencies. The small effect which it does have may be attributed to the partially swollen condition in which it leaves the wood, thereby permitting better penetration by the allyl chloride and a more complete formation of the hydrophobic layer over the internal surfaces of the wood.

The simple allylation treatment in which no catalyst was used was therefore developed. It was quite obvious from the results of this treatment that a competing reaction was present, i.e. the degradation of the wood in the presence of the allyl chloride. By employing higher temperatures and pressures, the effects of this degradation were studied (Table 1). Increases in both reaction temperatures and reaction times caused increased degradation which resulted in decreased weights and dimensions of the samples. This increased degradation however improved the dimensional stability of the samples, and in general reduced the water absorptivity. Similar findings were reported by Seborg, Tarkow and Stamm (6) who found that when wood is heated in an atmosphere of air or nitrogen, heat degradation of the hemi-celluloses of the wood results, yielding products of much less hygroscopicity than the original hemicelluloses, and imparting increased dimensional stability to the wood. At a given temperature however, heating in an atmosphere of allyl chloride yields wood of higher antishrink efficiencies than heating in air or nitrogen.

Conclusions

Dimensional stabilization by allylation is probably attained by a combination of the first and third group of treatment enunciated in the introduction, namely the coating of the internal structure of the wood with a water-repellent chemical, and the changing of very hygroscopic hemicelluloses into less hygroscopic derivatives.

These studies of the allylation methods show that allylation is superior to butylation for dimensional stabilization purposes. By a careful control of the conditions of allylation, it is believed that the degradation reaction may be minimized, at the same time aiding the formation of the hydrophobic polymer layer. Allowance may be made for the decrease in the wood strength which does accompany allylation by selecting uses for the wood wherein the affected strength is not a determining factor. The color of the wood is greatly enhanced by allylation, becoming a deep brown. The treatment is relatively simple and allylated wood is stable in water.

Further experimental work is planned to find methods of decreasing the degradation of the wood. Which strengths of the wood are affected by

allylation, and to what extent, must also be the object of further study. Possibilities of a vapor-phase treatment for allylation will also be investigated.

Work done on methods of allylation indicates that this treatment may be commercially valuable as a method of permanently increasing the dimensional stability of wood.

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Nailed Fir Plywood Gussets for Sawn Lumber Three-Hinge Arches[1]

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Nailed plywood gussets for sawn lumber 3-hinge arches are practical and competitive in cost with other types of framing as shown in this basic study conducted by the Plywood Manufacturers Association.

Introduction

THE CANADIAN FARMER has accepted glue-laminated wood construction for farm buildings. This type of structure is economical, exceptionally versatile and easy for the farmer to erect. Fir plywood is an excellent single finish material for arch rafter buildings but competition from other materials has limited its acceptance. Study has indicated that there is room for a structural system using fir plywood efficiently that is dependent upon fir plywood's mechanical properties for the transfer and distribution of loads.

A solution to the problem should provide all the advantages of a 3-hinge arch and have, in addition, other worthwhile features. Arches fabricated from sawn lumber by the plywood-lumber dealer or the farmer were considered. To transfer the bending moment around the haunch, fir plywood tension gussets were to be used, because plywood is stronger in tension than in compression and a buckling problem would not develop. The use of tension gussets would also simplify framing and fabrication of the arches.

The gussets, if glued to the lumber, could have been readily designed by standard methods. The disadvantages of gluing are that dry lumber is always required and fabrication by inexperienced workers could result in some failures.

The decision was made that a nailed plywood gusset might carry the expected loads.

Design

Design considerations: The spacing of the arches was set at 2 inch on center so that 5/16 and 3/8 inch fir plywood could be used as sheathing without purlins or blocking.

The snow load over a large area of the prairies does not exceed 30 pounds per square foot[2] and this figure is considered to be high in that little snow stays on the roof of buildings of this type located on the prairies. Many houses in Ontario have a roof structural system which, when tested in the laboratory, has failed at 20 p.s.f., yet they have not failed in use. Because 3/8 inch fir plywood roof sheathing with an asphalt emulsion coating weighs approximately 1 p.s.f. and the spanning members contribute 2 to 2-1/2 p.s.f., a dead load of 3-1/2 p.s.f. was assumed. In view of the nature and

[2] Climatological Atlas of Canada, DBR—No. 41, National Research Council.

Fig. 1.—Fir plywood gussets (2⅜ inch) on 2-by-8 studs and 2-by-10 rafters.

[1] Presented at the Eastern Canadian Section Meeting, March 1–2, 1956, in Toronto, Ont.

Author: F. G. Crofton was graduated from the University of Manitoba in mechanical engineering in 1951. He did work in the field of heating and ventilation engineering before joining the Plywood Manufacturers Association in 1951, as fieldman for Western Canada. In 1955 he was appointed to his present position where his efforts are devoted to developing fir plywood uses.

purpose of the structure and the above consideration, a total design load of 30 p.s.f. was considered reasonable. The arches to be spaced 2 feet apart were designed to carry a uniformly distributed load of 60 pounds per lineal foot.

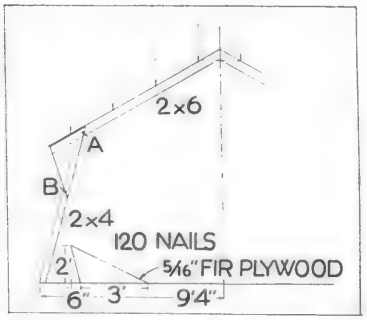


Fig. 2.—Eighteen-foot sawn lumber arch.

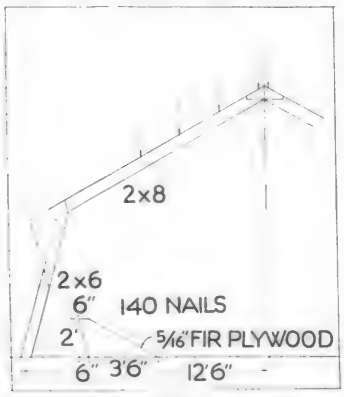


Fig. 3.—Twenty-four-foot sawn lumber arch.

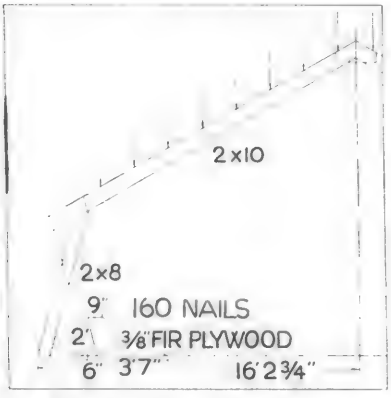


Fig. 4.—Thirty-two-foot sawn lumber arch.

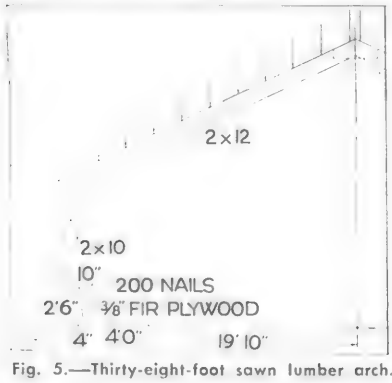


Fig. 5.—Thirty-eight-foot sawn lumber arch.

Tension Gusset Design: In general, reliable information was not available on the design of nailed, plywood-to-lumber, connections and little enthusiasm for the idea was encountered among persons consulted about the proposal. The designs had to be determined by cut and try, tempered with experience.

To obtain balanced construction and eliminate eccentric loading at the haunch, a gusset plate was placed on each side of the framing members. An estimate of possible bending moments indicated that 5/16 or 3/8 fir plywood could readily carry the tension loads. To check on this, and to evaluate three methods of nailing, six haunch sections were tested.

The tests indicated that double gussets attached with the smaller nails was the most efficient method of transferring the bending moment at the haunch. This haunch detail was used as a guide in all subsequent designs.

The size and shape of the gussets were determined by lofting efficient cutting patterns which made possible the distribution of the nails over a wide area of framing lumber. With the maximum bending moment known, it was possible to determine the thickness of plywood required and to estimate the number of nails needed for each haunch gusset. Because nails are inexpensive and authorities differ as to permissable lateral bearing strength, the quantities were arbitrarily increased and rounded off.

Design of Framing Members: Preliminary calculations indicated that the vertical member (or leg) did not carry as large a bending moment as the spanning member. The difference was sufficient to make the assumption that a 2 inch difference in depth could be safely maintained between the two members. For convenience and standardization, the smallest arch was composed of 2 x 4 leg and 2 x 6 spanning member; the 2nd of 2 x 6 leg and 2 x 8 spanning member; the 3rd of 2 x 8 leg and 2 x 10 spanning member; and the 4th of 2 x 10 leg and 2 x 12 spanning member.

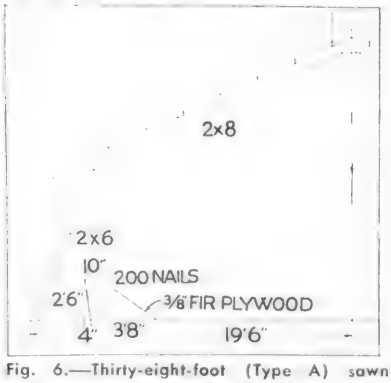


Fig. 6.—Thirty-eight-foot (Type A) sawn lumber arch.

The intention was that the arches be built with plywood and dimensional lumber available from local lumber yards, therefore an allowable bending stress of 1000 p.s.i. for the lumber members was assumed.

Using procedures outlined by T. R. C. Wilson in the U. S. Department of Agriculture Bulletin "The Design of Wooden Arches", it was possible, by cut and try, to determine maximum spans for each combination of framing lumber. Preliminary calculations indicated that the full-span uniformly distributed load was the critical loading for this shape of arch.

To reduce the bending moment at the haunch, the legs were sloped inward. The three smaller arches were standardized with 8 foot walls sloped 15° inward and roof slopes of 30°. The largest arch required a 20° slope on a 10 foot wall and a roof slope of 26° so that the span could be increased to over 38 foot using 20 foot roof members.

Five sawn lumber arches were designed. These are shown in Figs. 2–6 inclusive. The arches in Figs. 2, 3, 4 and 5 are of standard designs using lumber sizes as noted above. Details appear in a publication, "Rigid Frames and Glulam Arches for Fir Plywood Structures", prepared and released by the Plywood Manufacturers Association of British Columbia. The fifth arch (shown in Fig. 6) was designed to be comparable in strength to a 38 foot spruce glulam rafter as shown in Fig. 7.

Crown Hinge: The crown hinge was a plywood gusset held in place with approximately 10—1½ inch galvanized common nails. This gusset contributed little to the strength of the arch and served chiefly to ease the problem of erecting the specimen.

Construction of the Specimen

Plywood: 5/16 and ⅜ inch sheathing grade fir plywood, was obtained from a local retail source for the gusset plates.

Lumber: No. 2 spruce dimension, was obtained from a local supplier. It

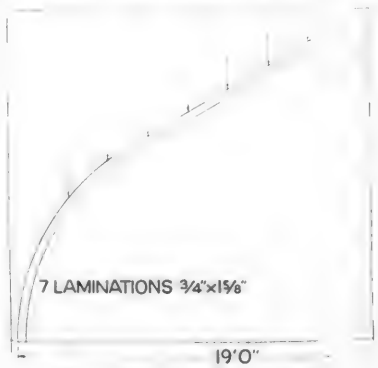


Fig. 7.—Spruce glulam rafter.

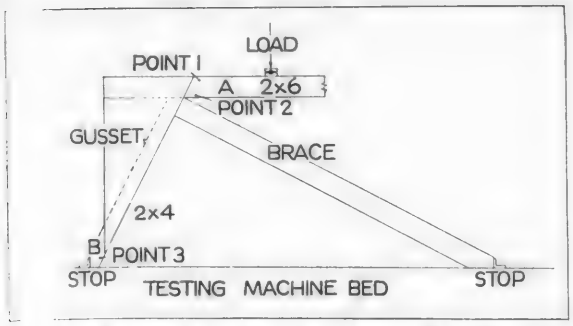


Fig. 8.—Haunch test specimen and method of loading.

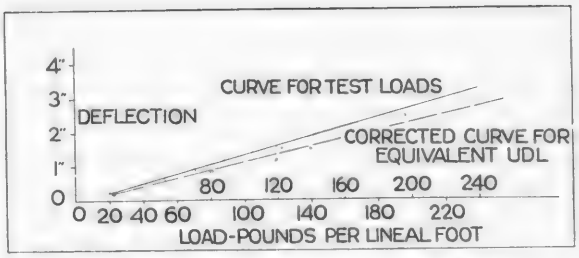


Fig. 9.—Sample load-deflection curve for a 32-foot sawn lumber arch.

was S4S and green. This material contained a large number of knots and was not selected in any way.

Nails: Possible splitting of the lumber members was eliminated by specifying 1½ inch galvanized common nails for attaching the gusset plates to all lumber members. The fabricator was instructed to stagger the nails and to space them evenly over the gusset. The cutting of the plywood and lumber was done either with a hand saw or an electric table saw by one man.

Assembly of the frames was done by a student who had no particular skill at carpentry and made some errors. The lumber did not always butt tightly at the joints. The workmanship involved in the construction of the test frames was similar, therefore, to that which might be expected in the field.

The size of the frame did not appreciably affect the time required to cut and assemble it. The average time taken for one man to cut and assemble two half frames was one hour. The lumber was green when the gussets were nailed to it. It was realized that the joint would lose strength as the lumber dried. A decision was made, therefore, to dry all frames before testing, to ensure that results would be conservative. The drying was done in the pilot tunnel drier at the University of British Columbia Agricultural Engineering Laboratory. Drying was very rapid and caused some checking of the lumber.

Glulam Arches: Three 38-foot spruce glulum arches were purchased from an Alberta supplier.

Erection and Testing

The five sawn lumber arches and one glulam arch (shown in Figs. 2–7) were erected by three men using a test jig which served to prevent lateral buckling of the test specimen as well as to absorb the thrust from the loaded frame. Buckling of the rigid frames while under test was the most troublesome problem encountered. The frame rested on blocks placed on the floor of the building. One end of the frame was placed on rollers so that the thrust could be measured with a hydraulic gauge.

Loading of the specimen was accomplished by attaching steel cables, at predetermined locations, to the spanning members. Adjoining cables in pairs were attached to the ends of steel bars and plywood tanks were suspended from the centers of the bars. By this method the load in each plywood tank was distributed equally to each supporting cable. The number of tanks was varied for each size of frame so that maximum loading could be imposed with the minimum number of tanks.

To achieve rapid loading, the tanks were loaded with water from two sources. Loading was controlled by the flow of water into the tank and could be corrected, if necessary, by letting water flow out of the bottom of the tank. In this manner it was possible to increase loading with reasonable accuracy. With the weight and size of tanks known, it was necessary to measure only the depth of water in the tanks to determine the loads being imposed on the frame at any given time. The objective was to load all frames to destruction.

An attempt to measure thrust by means of a hydraulic gauge was not successful because the results were not consistent enough to be of use.

Deflection at the crown was measured by attaching a scale to the crown of the frame and taking observations through a transit. Deflections were measured at the same time loads on the frame were determined. Load deflection curves were thus developed.

Discussion

The method of test loading the arches was successful in that desired load increments could be readily applied. The method of stabilizing the arches was not satisfactory because they tended to buckle between lateral supports. This buckling was not appreciable until approximately twice the design load was reached.

The plywood water tanks had nailed joints sealed with mastic. If the failure was a sudden collapse of the arch, the tanks dropped to the floor and often developed leaks. The problem was more frequent as the tests progressed and the nailed joints weakened. For inexpensive test loading, sandbags might be more convenient, even though the method would require more labor. A fork lift truck would reduce much of this work.

Six types of arches were tested. The 18, 24, 32 and 38-foot sawn lumber arches were designed for use in farm buildings. The 38 foot sawn lumber arch (type A) was designed to be comparable in strength to the 38 foot glulam arch purchased from a manufacturer in Alberta.

All arches tested failed in the lumber members. With one exception, the failures were due to the bending in

Table 1.—NAILING SPECIFICATION, MAXIMUM BENDING MOMENTS, AND TYPE OF FAILURE FOR HAUNCH TEST SPECIMEN

	Nailing	Maximum Bending Moment inch pounds	Type of Failure
I...	⅜" gusset		
	1½" galv. common nails into each member.	35,500	Member (A) split under gusset
		25,000	Member (A) split under gusset
IIa, 2	⅜" gussets		
	2¼" com. nails into each member—25 from each side, all were linched.	26,500	Member (A) split under gusset
		47,000	failure in bending at pt. 1
IIb, 10	⅜" gussets		
	1¼" galv. com. nails into each member—50 rom each side.	52,800	Member (A) split under gusset
		50,400	compression failure at knot — pt. 2

Table 2.—MAXIMUM BENDING MOMENTS SUSTAINED BY 18, 24, 32 AND 38 FT. ARCH GUSSETS

Nominal Arch Span	Maximum Bending Moment 60 lbs. per lineal ft. inch pounds	Maximum Bending Moment for Maximum Load inch pounds	Factor of Safety
18'	7,380	25,500	3.45
24'	13,800	56,600	4.11
32'	23,100	93,100	4.03
38'	30,900	142,400	4.61
38' A	29,700	81,600	2.75
38' Glu.	22,900	55,500	2.43

the lumber members. The exception was an arch which failed when lumber between the gusset plates split along a line of nails. The nailed gussets remained intact with only slight indications of nail deformation at critical points.

The maximum bending moments sustained by the 18, 24, 32 and 38-foot arch gussets (as shown in Table 2) indicated an average factor of safety of approximately 4 foot which is acceptable, though conservative. The maximum bending moment in the arch occurs at the junction of the leg and spanning members. (Point A in Fig. 2).

The strength of the arches tested is then determined by the quality of the lumber used and not by the nailed gussets. The common lumber expected to be used in the arches is not stress graded. This deficiency is countered by two points: First, the pamphlet published by the Plywood Manufacturers Association tells a fabricator how to select or grade the lumber; Second, the arches are used 24 inch o.c. Based on the theory of "multiplicity of members" the actual factor of safety of a building is thus increased.

At the beginning of this report it was stated that the allowable bending stress used was 1000 p.s.i. This figure is applicable to the grade of lumber specified. The actual stress at design load (as shown in Table 3) varied between 800 and 950 p.s.i. in both lumber members. The critical sections, in the spanning member and the leg, occur just above the gusset (Point A, Fig. 2) and just below the gusset (Point B, Fig. 2) respectively.

As noted in Table 3 the ratio of the crown deflection to the arch height was less than 1 per cent in the case of the four arches under consideration. This justifies an original assumption

Table 3.—ACTUAL STRESS AT DESIGN LOAD

Span		UDL of 60 Lbs. Per Lineal Ft.		Actual Loading			Minimum Failure Loads	
Nominal ft.	Actual Ft. in.	Total Load lbs.	Bending Stress p.s.i.	Bending Stress p.s.i.	Equiv. UDL lbs.	Deflection at crown def. ins.	Def. Height	Equiv. UDL lbs.
18 span	18′ 4″	1100	862	936	65	0.75	1/193	155
leg			948	1251	79			
24 span	24′ 6″	1470	907	1735	115	0.56	1/291	247
leg			846	1766	125			
32 span	31′ 10″	1910	946	1064	66	1.16	1/159	188
leg			823	995	73			
38 span	38′ 11″	2340	863	1085	76	1.50	1/138	179
leg			808	1105	82			
38A span	38′ 1″	2280	1950	2225	67	2.66	1/78	81
leg			2220	2930	79			
38 Glu.	38′ 0″	2280	3070	3310	65	2.72	1/86	119

that the secondary stresses could be ignored.

A comparison of the results of testing the 38 foot sawn lumber arch and the 38 foot glulam arch shows that the former is considerably stronger. This fact can be used to justify the assumption that a 30 p.s.f. design load is sufficient for the application proposed for the sawn lumber arches, as this type of glulam arch is in common use throughout Canada and the United States.

The 38 foot sawn lumber arch (type A) was designed and proved to be comparable in strength to the 38 foot glulam arch. The 38 foot Type A arch was fabricated using 2 x 6 inch and 2 x 8 inch framing members rather than 2 x 10 inch and 2 x 12 inch members specified for the 38 foot standard arch.

Conclusions

The idea of nailed plywood gussets for sawn lumber 3-hinge arches is sound, practical and competitive in cost with other types of framing.

The use of non-stress graded lumber is acceptable as long as the fabricator follows directions in the Association pamphlet.

The use of small nails (or special nails) reduces the possibility of splitting the lumber members. Numerous small nails produce a more satisfactory connection between the plywood and lumber because of the wider distribution of the loads over the structural members.

This construction system uses materials every lumber dealer normally carries in stock.

The work done to date does not constitute a thorough investigation of nailed plywood gussets. It does show however, that the four standard arch designs are satisfactory and indicates that this field, apparently neglected to date, offers scope for further development.

Remarks

Investigation into nailed plywood gussets should be conducted to provide information that would allow the selection of a thickness of plywood, and size of nail for a given type and size of lumber.

Work might also be done on gussets for specific purposes (e. g. sawn lumber arches, splicing lumber to transfer bending moments, rigid frames)

Fig. 10.—A 32- by 80-foot rigid-frame turkey shelter under construction at University of British Columbia.

Fig. 11.—Finished 32- by 80-foot rigid-frame turkey shelter University of British Columbia.

Comparison of Standard Block-Shear Test with the Panel-Shear Test

CHARLES B. NORRIS

Engineer, Forest Products Laboratory[1], Forest Service,
U. S. Department of Agriculture

Matched specimens were made, divided into groups, and conditioned in different atmospheres before being subjected to block-shear and panel-shear tests. Near-agreement in shear-strength values was obtained. Data presented includes individual shear test results and a comparison made of average values.

Introduction

THE ASTM (1)[2] STANDARD SHEAR TEST for small, clear specimens of wood (Figs. 1 and 2) was developed by the Forest Products Laboratory about 1910. At that time, it was realized that the test did not subject the specimen to uniformly distributed pure shear. Over the years, the limitation has been commented on by a number of investigators, notably by Coker and Coleman (3) and, more recently, by Radcliffe and Suddarth (7) and by Meadows (4).

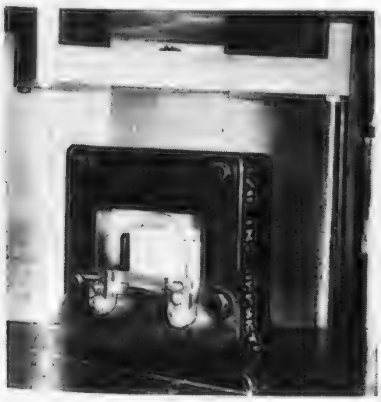
These inadequacies are applicable to the elastic range only. The shear stress is not distributed uniformly across the shear plane; other stresses than shear act on this plane, and stress concentrations do occur at the re-entrant corner and the opposite corner of the specimen. It is difficult, however, to devise a simple specimen that is much better. Radcliffe, Suddarth, and Meadows suggest the use of beam specimens, but these are subject to all the criticisms brought against the block shear specimen.

A very satisfactory shear specimen developed for plywood has also been used successfully for solid wood. It is called the panel shear specimen. This specimen is described in Forest Products Laboratory Report No. 1328–C (5). The specimen consists of a wood panel cut in the form of a cross (Fig. 3). Wood blocks are glued to the arms of the cross, upon which are mounted steel rollers centered on the inner surfaces of the blocks, as shown in Fig. 4. In the test, wedge-shaped pieces apply forces to the rollers in the direction of the edges of the wood blocks, as shown in Fig. 5. Thus the central square part of the specimen is subjected to a shear stress. Tests in which resistance-wire strain gages were attached to the surfaces of the specimens showed that the shear strains are nearly uniformly distributed over the test area of the specimens. Figs. 6 and 7 show modified apparatus.

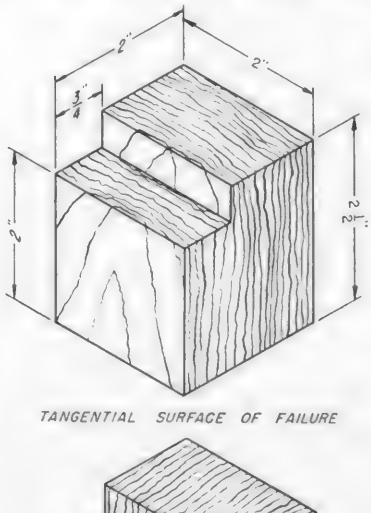
Shear strength values of plywood obtained with this apparatus are compared to values obtained by the block-shear method in Forest Products Laboratory Report No. 1801 (6). These tests included solid wood specimens. The average results of these tests are

[1] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.
[2] Numbers in parentheses refer to Literature Cited.

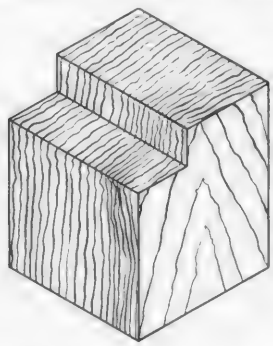
The Author: Charles B. Norris received a B.S. degree in mechanical engineering from the University of Wisconsin. After three years with the Forest Products Laboratory, he spent more than 20 years with private industry, returning to F.P.L. in 1942. He is engaged mainly in the development of design criteria for plywood, structural sandwich construction, and glass fiber laminates.



g. 1.—Standard shear tool for the block-shear test.



TANGENTIAL SURFACE OF FAILURE



RADIAL SURFACE OF FAILURE

Fig. 2.—Standard block-shear specimen.

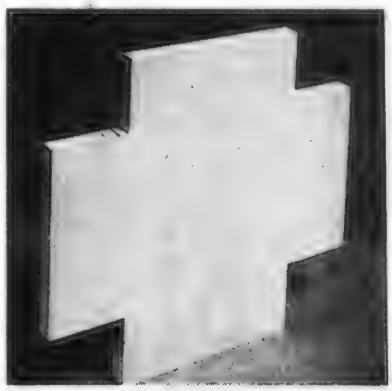


Fig. 3.—Panel-shear specimen.

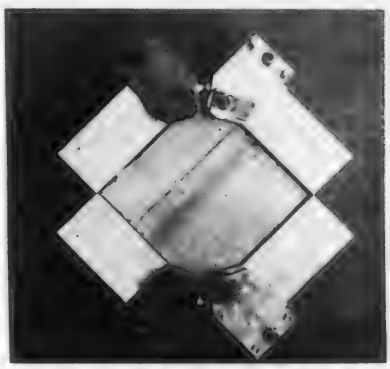


Fig. 4.—Panel-shear specimen with glued blocks and rollers in place.

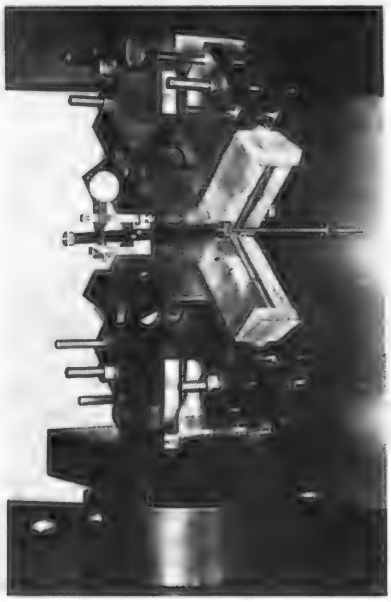


Fig. 5.—Panel-shear specimen and apparatus set in testing machine ready for test.

Fig. 6.—Modified panel-shear specimen with roller bearings glued in place.

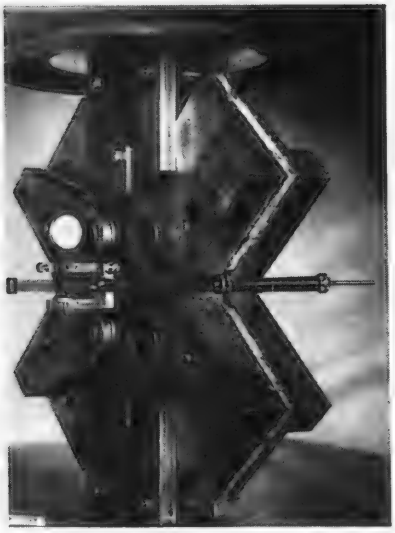


Fig. 7.—Modified panel-shear specimen and apparatus in testing machine ready for test.

given in report No. 1801 but were not analyzed to compare the two kinds of shear tests.

It is the purpose of this paper to focus attention on these results and their significance.

Test Specimens

Matched specimens of the block-shear and panel-shear types were made from Douglas-fir, yellow-poplar, yellow birch, and sweetgum.

Douglas-Fir Specimens: Two Douglas-fir logs were quartered into flitches. Quarter-sliced veneers were made from these flitches (6). The backboards of the flitches were cut into block-shear and panel-shear specimens. Five panel-shear specimens were cut from each of six backboards, and about ten block-shear specimens were cut from each of these boards. In these specimens, the shear planes were parallel to the longitudinal and tangential directions of the wood. The panel-shear specimens were 0.630 inch thick, and the central portion of the cross was 5 inches square. The block-shear specimens were of the standard size shown in Fig. 2.

The specimens from each log were divided into three groups and conditioned in different atmospheres before being tested. These atmospheres were controlled at temperatures and relative humidities as follows: (1) 80° F. and 80 per cent; (2) 75° F. and 6[illegible] per cent; and (3) 80° F. and 30 per cent.

Yellow-Poplar, Yellow Birch and Sweetgum Specimens: Yellow birch, yellow-poplar, and sweetgum were cut into bolts 4–½ feet long, from which rotary-cut veneer was made (6). The log ends were cut into standard block-shear and panel-shear specimens. The shear planes in these specimens were parallel to the longitudinal and radial directions. The panel-shear test specimens were made of strips of wood glued together, radial surface to radial surface. They were 0.32 inch thick, and the central part of the cross was 3–½ inches square. Ten panel-shear specimens and ten block-shear specimens were made from each log and were conditioned before test in an atmosphere held at 80° F. and 80 per cent relative humidity.

Results of Tests

Data obtained from the individual shear tests of Douglas-fir are given in Tables 1 and 2. Data obtained from shear specimens of various hardwoods are given in Tables 3 and 4. The moisture content values given in these

Table 1.—MOISTURE CONTENT AND SHEAR STRENGTH VALUES OF VARIOUS DOUGLAS-FIR SPECIMENS AS OBTAINED FROM STANDARD BLOCK-SHEAR TESTS

Test data					
Moisture content Per cent	Shear strength P. s. i.	Moisture content Per cent	Shear strength P. s. i.	Moisture content Per cent	Shear strength P. s. i.
Piece A		Piece B		Piece C	
16.2	1,350	16.7	1,109	12.2	1,550
16.5	1,422	16.2	1,012	11.8	1,484
16.5	1,256	16.6	948	11.0	1,346
17.0	1,112	16.3	1,012	12.1	1,398
16.5	1,209	16.1	952	12.2	1,524
16.0	1,238	16.3	1,044	12.1	1,407
16.7	1,110	16.7	1,032	12.4	1,546
15.6	1,308	16.8	904	11.9	1,554
16.1	1,358	----	-----	11.0	1,394
16.6	1,162			12.0	1,616
Av. 16.4	1,252	16.4	1,002	11.9	1,482
Piece D		Piece E		Piece F	
11.7	1,196	6.5	1,487	6.5	1,375
11.4	1,176	6.5	1,482	6.5	1,290
11.5	1,132	6.2	1,422	6.7	1,240
11.7	1,222	6.4	1,361	6.6	1,099
11.8	1,133	6.5	1,461	6.6	1,214
11.5	1,208	6.4	1,337	6.9	1,390
11.7	1,084	6.3	1,315	6.5	1,164
11.9	1,112	6.2	1,426	6.5	1,250
11.3	1,238	6.8	1,456	- -	- -
11.5	1,244	6.6	1,534		- -
11.5	1,338	----	--		
11.5	1,158		- -		- -
11.6	1,175				- -
Av. 11.6	1,186	6.4	1,428	6.6	1,252

Table 2.—MOISTURE CONTENT AND SHEAR STRENGTH VALUES OF VARIOUS DOUGLAS-FIR SPECIMENS AS OBTAINED FROM PANEL-SHEAR TESTS

Test data					
Moisture content Per cent	Specific gravity	Shear strength P. s. i.	Moisture content Per cent	Specific gravity	Shear strength P. s. i.
	Piece A			Piece B	
15.5	0.452	1,430	15.6	0.365	900
15.9	.450	1,530	15.8	.397	980
14.0	.439	1,270	16.6	.410	1,060
15.8	.482	1,390	16.4	.424	1,020
15.8	.453	1,390	16.2	.398	780
Av. 15.4	.455	1,400	16.1	.399	940
	Piece C			Piece D	
12.0	.516	1,826	11.0	.395	900
11.9	.516	1,830	11.0	.397	940
12.1	.502	1,820	11.0	.430	1,040
12.2	.536	1,860	11.6	.431	980
12.8	.517	1,870	11.8	.427	1,060
Av. 12.2	.517	1,840	11.3	.416	1,000
	Piece E			Piece F	
7.5	.486	980	7.3	.445	930
7.1	.485	1,310	6.9	.448	940
6.9	.446	1,150	7.5	.437	880
7.2	.457	1,390	7.4	.451	970
7.2	.514	1,260	7.2	.442	970
Av. 7.2	.478	1,220	7.3	.445	930

Table 3.—MOISTURE CONTENT AND SHEAR STRENGTH VALUES OF VARIOUS HARDWOODS AS OBTAINED FROM STANDARD BLOCK-SHEAR TESTS

Test data					
Yellow-poplar		Yellow birch		Sweetgum	
Moisture content Per cent	Shear strength P. s. i.	Moisture content Per cent	Shear strength P. s. i.	Moisture content Per cent	Shear strength P. s. i.
18.5	814	16.0	1,819	17.8	1,448
18.8	884	15.2	1,806	18.0	1,435
18.6	897	15.8	1,827	18.3	1,478
18.2	922	16.0	2,120	18.5	1,489
18.2	1,012	15.3	2,142	18.6	1,496
18.5	1,018	15.1	2,110	19.0	1,582
18.5	1,000	15.4	1,999	18.9	1,634
18.4	1,033	15.0	2,022	19.0	1,614
18.5	992	15.6	1,626	18.8	1,619
18.5	1,033	15.5	1,642	18.5	1,458
Av. 18.5	960	15.5	1,911	18.5	1,525

tables are based on the oven-dry weight of the specimens. The specific gravities given in Table 2 are based on oven-dry weight and volume at test.

Average values obtained from the panel-shear and block-shear tests are compared in Table 5. The adjusted average shear-strength values listed in column 6 are those of column 5 adjusted from the moisture content values of column 4 to those of column 2. Shear strength was increased 3 per cent to adjust for each 1 per cent decrease of moisture content in accordance with the procedure given on page 85 of the Wood Handbook. (2) The values in column 7 are the ratios of those in column 6 to those in column 3 and show how well the results of the block-shear test values agree with the panel-shear test values.

The agreement in the shear strength values obtained by the two test methods is remarkable. In the panel-shear specimen, substantially pure shear strain is applied to the specimen, and this shear strain is substantially uniformly distributed throughout the test volume of the specimen. This is true for all strains up to those at which failure takes place. Thus it is true in the plastic range as well as in the elastic range of strain. In the block-shear specimen, it is known that severe stress concentrations exist in the elastic range of the strain. (3) It is not known, however, what changes in strain distribution take place when the strains move into the plastic range. The results of the tests reported here suggest that a state of nearly pure plastic shear stress that is distributed approximately uniformly across the shear plane is set up before failure.

Other tests made at the Forest products Laboratory indicate that the shear-strength values obtained by the block-shear test decrease as the friction in the block-shear tool is decreased. Thus, with a frictionless tool, the block-shear test would yield shear-strength values less than those obtained by the panel-shear test. This suggests that some stress concentration exists in the block-shear specimen even in the range of plastic strains. The effect of this concentration is approximately compensated for by the friction of the standard tool used in these tests.

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Table 4.—MOISTURE CONTENT AND SHEAR STRENGTH VALUES OF VARIOUS HARDWOOD AS OBTAINED FROM PANEL-SHEAR TESTS

Panel-shear tests								
Yellow-poplar			Yellow birch			Sweetgum		
Moisture content Per cent	Specific gravity	Shear strength P. s. i.	Moisture content Per cent	Specific gravity	Shear strength P. s. i.	Moisture content Per cent	Specific gravity	Shear strength P. s. i.
17.6	0.348	924	13.4	0.640	1,766	17.6	0.640	1,742
17.6	.338	987	12.6	.640	2,067	15.5	.651	1,838
18.1	.369	927	12.8	.634	1,704	17.7	.624	1,818
17.6	.373	1,088	13.0	.656	1,666	15.3	.627	1,824
18.0	.365	852	12.6	.638	1,822	17.3	.648	1,776
17.0	.352	1,185	13.6	.639	1,795	17.2	.644	1,770
17.4	.349	1,014	12.6	.637	1,786	17.2	.654	1,888
16.6	.338	919	13.2	.643	1,742	17.0	.670	1,837
17.2	.387	852	13.2	.634	1,775	17.1	.650	1,698
17.4	.345	830	---	---	---	16.6	.656	1,697
Av. 17.4	.356	958	13.0	.640	1,790	16.9	.646	1,789

Table 5.—COMPARISON OF BLOCK-SHEAR WITH PANEL-SHEAR STRENGTH VALUES

		Panel shear		Block shear			
Species (1)	Piece (2)	Moisture content (3) Per cent	Shear strength (4) P. s. i.	Moisture content (5) Per cent	Shear strength (6) P. s. i.	Adjusted shear strength (7) P. s. i.	Ratio (8)
Douglas-fir	A	15.4	1,400	16.4	1,428	1,470	1.05
	B	16.1	940	16.4	1,002	1,010	1.07
	C	12.2	1,840	11.9	1,482	1,470	.80
	D	11.3	1,080	11.6	1,186	1,196	1.11
	E	7.2	1,220	6.4	1,428	1,393	1.14
	F	7.3	930	6.5	1,252	1,222	1.31
Yellow-poplar	--	17.4	958	18.5	960	993	1.04
Yellow birch	--	13.0	1,790	15.5	1,911	2,060	1.15
Sweetgum	--	16.6	1,789	18.5	1,525	1,614	.90
						Av.	1.06

Producing Slender Turnings at Automatic Lathes

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AT THE AUTOMATIC shaping lathe, a certain amount of cutting thrust is inevitably imposed against the revolving turning from behind, as the cutters engage the stock. Where turnings are short, or of relatively-large diameter, or both, little attention need be paid to cutter thrust so far as setting up vibration in the turning is concerned. However, as turning blanks increase in length, or decrease in diameter, or both, there is increased danger of pronounced vibration. Therefore, manufacturers of these machines provide steady rests, which can be made to bear against the turning from below and from the front, to counteract cutter thrust and prevent vibration.

Where very slender turnings of any considerable length are being machined between centers in any type of lathe, the end pressure which is necessary to properly hold a turning between centers always has a tendency to buckle it, or spring it out of a straight line. Any vibrating tendency set up by cutter thrust on an automatic shaping lathe automatically combines with such buckling tendency, thereby increasing the chance of trouble in this respect.

Automatic shaping lathes may be fitted with a special hollow chuck in order to overcome this trouble. The hollow chuck, where used, replaces the end-pressure action of the tailstock while turning is actually in process. It may be moved along the length of the turning to any desired point, with the turning passing directly through it. Where a hollow chuck is used, the tailstock is used only initially, to exert primary end pressure necessary for chucking the blank into the headstock center.

Fig. 1.—Automatic shaping lathe in operation on a turning sufficiently slender that a steady rest is used. The front steady rest is engaging the front of the turning to prevent any vibrative action. Photo courtesy Mattison Machine Works, Rockford, Ill.

The hollow chuck employed has self-centering, V-shaped jaws. The jaws close upon and grip the slender turning close up to the cut being made. Tailstock pressure is then released, whereupon the jaws of the hollow chuck, revolving with the material, hold it firmly without any end pressure. The jaws are opened and closed on the work with a quick-action crank. They are equipped with a positive locking action, allowing the turning to revolve either with or against the direction of cutter rotation, without any danger of loosening. The hollow chuck, in addition to relieving the turning of end pressure, provides so much additional support that it results in far smoother turning wherever it can be used.

Employing such a chuck, two ends of the same slender long turnings may be separately supported and turned where desired. A special stock-centering device is used with the chuck, allowing turning blanks to be automatically and perfectly centered on the headstock center. The centering device automatically drops back out of the way, however, as the turning carriage moves toward the cut. Consequently, it does not interfere with the subsequent operation. Knife cuts may be made completely out over the ends of turnings in cases where it appears advantageous to do so.

Automation in the Planing Mill[1]

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The lumber industry has not kept pace with the level of control and efficiency other industries have attained. Use of automated production control processes; automatic sorting, handling, grading, trimming and finishing; and statistical correlation of sales to inventory are steps that should be undertaken.

Introduction

THE WORD "AUTOMATION" may have different meanings in different industries. When used in connection with a lumber mill, it means bringing the industry to the level of control and efficiency that other industries have maintained for years.

This means well developed and meticulously maintained processes, data, information and standards that enable industry to forecast, measure, control and predict the scope, direction and pace of operations. This includes measuring and forecasting profits relation to costs of materials and labor, volume of business and capital investment.

If complete statistical and physical control of lumber can be achieved in every step of the manufacturing process, the industry will have a good beginning towards automation.

Production Control Unit

Means of achieving this might be understood best by studying a hypothetical situation, beginning with the production control unit.

In addition to a well-trained staff the unit will include the services of some type of advanced design tabulating equipment.

It also will include three electronic computing and registering panels showing continuous piece count and board feet figures for each item processed in three areas:

(1) Off the green chain.

(2) Out of the dry sorter-blanked and remanufactured.

(3) Finished goods applied against shipping invoice and left overs on the planing mill floor.

The production control unit will prepare production time tables for three points of in-process inventory:

(1) Log inventory and selective logging schedule of species and quantity (approximately 20 to 30 per cent of all logging).

(2) Timetable loading into kilns of stickered lumber units based on sales order priority and kiln operation efficiency.

(3) The scheduling of semi-finished (blanked) lumber into planing mill or rough storage as sales order priority and planing mill operation efficiency determines.

The production control unit will be responsible for the accumulation, evaluation and application of pertinent manufacturing data and information required for forward planning, cost control and measurement of operating efficiency.

Order Processing

Under this system, how would a sales order be processed?

Assume business is part mixed and part straight car, with sales on a quarterly basis on salesmen's orders, and mail, teletype and telephone inquiries.

In the production control procedure all-sales orders will be processed through the tabulating system to reduce the entire order file into green lumber terms and quantities, possibly in eight hour or four hour periods in order to provide constant and accurate data of manufacturing requirements.

Inquiries usually are based on a date or selective item need basis. Quick review of the logging inventory and cutting schedule, the lumber production schedule by species and inventory figures will provide rapid and efficient acceptance or rejection of every inquiry.

The order file breakdown records would be situated near the computing and registering panels showing the piece count and board-foot tally figures of lumber coming off the green chain.

Green chain equipment would include completely automatic handling and sorting facilities. One of several sorting methods might be used but assume that a gravity deck or tray system has been selected.

As the green lumber passes out of the trimmer a grader would press a specific button on an electrical key console to sort the board automatically for species, length, width, thickness and drying quality into a particular tray.

As the board enters the tray a light beam, switch or other device would try the mechanism that would register the piece count and board—foot tally on the green lumber computing and registering panel.

Sorted by Volume

The higher volume items would be processed through the sorting mechanism through the trays and automatically stacked and stickered into 5 x 5 foot packages.

The lower volume items would be sorted for length and width only then transferred to a holding area to be resorted, stickered and stacked on off hours or third shift.

The packages would be moved mechanically into the in-process inventory area or stacked directly onto kiln cars, depending on the kiln drying time table prepared by production control.

The stickers used for drying would be of an aluminum extruded shape with a hook on one end for automatically pulling each package as the package moves on a roll case after being taken down from the kiln load.

The dead pile packages would then be moved into an in-process inventory (depending on production timetable) area, or moved directly to blanking and remanufacturing equipment (for boards) or finishing, splitting, waxing, stamping and remanufacturing equipment (for dimension).

The entire output of this semi-finishing, finishing and remanufacturing area will be automatically handled and electronically sorted and distributed into decks or trays by species, length, thickness and grade. Each item will be computed by board-foot and piece-count tally in dry lumber terms and the amounts registered on the control panel.

The boards and dimension lumber passing through the sorting and computing apparatus will be handled in three ways:

(1) Blanked boards will be 95 per cent on grade and will be trans-

[1] Presented at the Northern California Section Meeting, Sept. 28, 1956, in Reno, Nev.

ferred via tipple and belt conveyor to the finish planer when the material being processed fits directly into the finished production timetable and/or the shipping schedule.

(2) Blanked boards, sorted and on grade not fitting into the production timetable, will be stacked automatically into units for rough goods inventory.

(3) Finished dimension lumber waxed and stamped 100 per cent on grade and fitting into the shipping schedule, will be stacked and banded automatically in sales order amounts and transferred directly to the shipping dock.

Finished dimension not fitting into the shipping schedule will be automatically stacked and transferred to finished goods inventory.

Production control from the stump to the box car would include semi-sorting of logs by species in the woods, and finish sorting by species in the pond.

Correlation of Sales to Inventory

The breakdown of the sales order file is matched with the inventory figures of stacked green lumber units, dead pile units of dry lumber and semi-finished and finished lumber. Production control then can plan and order sawing production hours by species. Species are changed as order requirements and process lead time dictate.

"Selective item" and "date needed" inquiries and special sales order requirements can be handled by selective logging. This probably will amount to 25 or 30 per cent of all logging operations. This also could be handled by developing data and information of the product yield by boards or dimension of different sizes of logs by species.

The logs could be sorted by grade and species: No. 1, one to five logs per thousand; No. 2, six to ten; and No. 3, 11 or more. They won't be sorted by grade in inventory in any part of this program. But when production control has need for logs other than common items either the pond crew or logging operations will be requested to bring in the quantity needed.

Need for Improved Processing Methods

The lumber industry may be following sound policy by processing each item over the same equipment in the same manner, regardless of the return from the end product. But is this really the practical and economical thing to do?

Some day the problem of most efficient utilization of raw materials by determining true end product worth will have to be faced. It would be better for the industry to make the decisions, rather than have them forced upon them.

Progress being made in other industries is evident. Recently the U. S. Bureau of Standards approved and adopted a new grade process for leather. Leather grading has been a problem for years and high prices made the situation unbearable to the industry.

Sheer necessity forced the problem into the research laboratory. It was not long before a method and equipment were produced using ultrasonic sound waves that measured fibre quality and fibre orientation quickly and accurately thus determining grade.

Conclusion

Automation is a difficult subject to talk about in the lumber industry. But if lumber is going to keep pace in our present industrial economy increasing emphasis will have to be placed upon more efficient and economical means of operations.

The Past Developments and Future Prospects for Compreg

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Early wartime development and utilization of compreg and subsequent demise following World War II are traced. Examples of increasing demand and production throughout the world are cited. The future for utilization by textile, cutlery and electrical industries are pointed up.

Introduction

THE YEAR 1957 MARKS the 16th anniversary of the commercial introduction of resin impregnated densified wood, commonly known as compreg, to the United States.

Where does compreg stand today as a material of industry and commerce? What future development may be expected? [1]

[1] Much of the information and opinions that follow reflect the author's experience and close association with the development of compreg since its inception and are not necessarily taken from records or documents; there being very little, if any, statistical or written information on many aspects of the subject. Any corrections and differences of opinion that will bring the subject into clearer focus are, therefore, welcomed.

Wartime Uses

In early 1942 the compreg propeller was accepted by the Air Force for use on trainer planes. Total number of propellers produced during the war was in the vicinity of 10–12,000 units. The original propeller designs were deliberately conservative because of inexperience with this new material. By 1943 sufficient experience had been gained so that an attempt was made to equal the aerodynamic performance of an aluminum counterpart.

Tests showed the new design to be distinctly superior in aerodynamic performance and proved that the material could be made into thinner airfoil sections successfully. Just before the war ended, a compreg propeller was designed for the P–51, then the fastest plane in existence. These blades were tested at Wright Field and found equivalent in performance to the steel blades with which this plane was equipped normally.

The compreg propeller was also approximately 100 pounds lighter than the steel one, a most important advantage. This last design never got beyond the experimental stage for the war soon ended. Maximum consumption of compreg for propellers occurred in 1944 when nearly one-million pounds was used for this purpose. Compreg also was used for test clubs, antenna masts and other miscellaneous rod-

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ucts. These items accounted for not more than 300–400,000 pounds in 1944. The maximum annual compreg consumption during the war, which occurred in 1944, was, therefore, approximately 1¼ million pounds.

Demise After War

Immediately following the end of the war, the use of compreg dropped to negligible proportions. Of the four or five wartime producers, only two remained active. As the years went by, the demand for compreg developed slowly in other directions. The cutlery field has become a large consumer of this material. It is estimated that in 1955 a minimum of 1–1½ million pounds went into cutlery handles alone.

In addition, the textile industry has become a fairly substantial consumer of compreg picker sticks and loom parts. Some compreg is being used as forming dies, and small quantities are being made into gears. In addition to the above uses, molded compreg is being produced by one company in this country in the form of desk legs and other furniture parts. Based on the foregoing, 1955 saw two-million pounds or better of compreg consumed, marking it the greatest consumption year to date, inclusive of war years.

The number of compreg producers has now again increased to five. The one company producing molded compreg parts only is included in this figure. In addition, one of the largest producers of this material in Europe is now in the process of setting up a plant in the States for the production of compreg.

International Picture

What is the international picture on compreg production and development?

Most of the compreg manufactured outside of this country is produced in Europe. It is believed that the original producer of compreg was a French company which developed the product several years prior to its development in the United States. Today England has four companies, one of which distributes its products throughout the world. Germany also produces this material, and the production of molded compreg parts is of substantial importance in that country. Molded compreg knife handles made from beech veneer have been imported to the United States for some time. At least one company in Japan is producing compreg for commercial industrial applications.

Russia is known to have used compreg during World War II as spar flanges in her MIG, LAGG and YAK planes. Since hardwood veneer has been generally used in manufacturing compreg, it is particularly interesting to note that Russia used pine veneers successfully in making compreg of very good properties. Some work was done on compreg in Australia and India, but its current status in these countries is unknown.

In Europe, compreg has gained much wider recognition than it has in this country and is used in many important industrial applications. The various branches of the electrical industry are large consumers, using this material for insulating components subject to severe mechanical stress. Some examples are oil circuit breakers, supports for terminal connections and end windings in generators, structural members in transformers, and staywire insulators and H-frame supports in high voltage line transmission.

Compreg is also used overseas for silent gears, pulleys, metal forming dies, textile loom components, chemical industrial applications subject to mild acid, mild alkali, or organic solvent action, and for filter press components. Compreg produced in Europe is being used by railroads in many parts of the world, including the Tropics, for rail fish plates and for rail sole plates.

Comparison of Properties

The properties of European compreg are quite similar in mechanical and physical characteristics to American-made compreg except for impact strength. The izod impact strength of the material is of the order of 7 foot-pounds per inch of notch, whereas European material is at least two to three times tougher. The type of resin used for impregnating accounts for this difference. Cresols are used predominantly overseas, whereas phenols are used in this country.

It is a well-known fact that phenol resin reduces the inherent toughness of wood and produces a relatively brittle product. This important difference in properties emphasizes the effect of the resin type on the finished product, and points up the need for continued research for better resin impregnants. The phenol currently used in this country is the same resin that was used 15 years ago.

Little or no research is being carried on along these lines by the resin producers in this country. The Forest Products Laboratory, which was the fountainhead for much information and research on this subject in former years, has done little or nothing in this direction for some time. This is most regrettable.

Future Outlook

What lies ahead for compreg? What future developments may be expected from this material?

Before proceeding a brief comparison of some of its mechanical properties and that of other materials should be made. Using a figure of 35,000 pounds per square inch for its tensile strength, compreg is nearly three times as strong as the usual fabric laminates, and more than twice that of paper laminates.

Compreg is one of the strongest cellulosic laminates yet created. Its strength/weight ratio in tension is superior to that of steel and aluminum and nearly equal to that of magnesium. Its dimensional stability and electrical resistivity are both good.

The cost of compreg compares most favorably with that of paper and fabric high pressure laminates as proven by production experience.

For these reasons and because of its successful performance in Europe, compreg probably will become increasingly important as a structural insulator in the electrical industry, supplanting paper and fabric base laminates in many applications.

The largest consumer of compreg today, the cutlery industry, has not reached its saturation point. Consumption will increase and it is not unreasonable to expect a 75–to–100 per cent increase in annual usage within the next three to five years.

The textile industry will continue to be a steady consumer. Some highly technical applications, such as helicopter blades and ball bearing cages, warrant consideration of compreg as a construction material. Railroads and aircraft also offer a potential market for this material. Because of today's high cost of hardwood plywood, the development of compreg surfaced, prefinished panels is already being investigated by a plywood manufacturer.

As engineers and designers become more familiar with the excellent properties of compreg, many new applications will develop.

Summary

Compreg is here to stay. Its growth will continue. In the not too distant future it will be a most substantial and respected member of the wood products field.

Treated Farm Posts—Their Sales in a Test Area[1]

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Following a market research study, a sales program for treated building materials was concentrated in three Midwest states. The market potential was measured, distribution channels established, and a promotional campaign aimed at developing farmer interest. Market expansion resulted, pointing to greater consumption of treated products by both farm and commercial construction industries.

Introduction

AS FAR BACK AS 1946, Dow had begun national advertising directed toward the farm and home markets in an attempt to increase the sale of pentachlorophenol through treated forest products. The late 1940's were a period of feeling our way in both the farm and home market, learning the techniques of selling these large potential markets. As could be expected, most of the advertising and promotional literature, which was of an educational nature, was directed primarily at the consumer. (At that time, little awareness of preservative treated forest products was found in either the farm or home market.)

After a year or two, it was apparent that the educational advertising was not resulting in any great immediate demand for treated building materials. The feeling was that national advertising was spread so thinly, in both the farm and home market, that it did not have enough impact to motivate the mass sale of treated materials. The problem, therefore, which faced the sales management in the early 1950's was how to concentrate available advertising dollars and manpower to obtain this impact and thus obtain greater effectiveness and dollar return.

Several alternative courses were open: continue shot-gun advertising nation-wide directed toward the farm and home market; concentrate on either the farm or home market on a national basis; regionally in both markets; or regionally toward only one of the two markets.

National advertising of treated forest products for either the farm or home market was felt to be ineffective with a limited budget. Therefore, it was decided to concentrate on one field and develop it regionally. At this point the market research department was requested to study both markets to determine where major emphasis should be placed.

Survey Results

Both fields offer sizeable potential markets for treated materials. However, surveys tended to show that the farm field would be a much more receptive market.

In the home field, studies showed:

(1) Speculative builders who account for 75 per cent of new residential construction, generally are not interested in using treated lumber.

(2) At the time of the surveys, the Federal Housing Administration's attitude was that treated lumber is not the answer to the termite problem. Unless the FHA requires treated lumber, most builders will not use it.

(3) In addition to the opposition of builders, most home owners are not "quality" conscious in regard to the building materials used in their homes.

(4) The marketing of treated lumber to the home field has always been a difficult problem since retailers are hesitant to carry duplicate stocks of lumber.

On the other hand, in the farm field, it was found:

(1) There is much more awareness of the need for treated wood among farmers. The educational job is not as hard.

(2) Since farmers are interested in maximum life from their investments, they present a more receptive market for treated wood products than most home builders.

(3) In addition, there is a more serious decay and termite hazard in the farm field since much of the wood used is in direct contact with the ground.

(4) The channels of distribution for treated poles and posts were well established.

(5) The growing trend toward pole-type farm buildings made the farm market look very attractive.

Therefore, it was recommended that for the immediate future efforts would be concentrated on the farm market. This did not mean the potential for treated wood products in the home construction field was small—only that more could be accomplished by concentrating efforts in the farm field for the present.

It was impossible to accurately predict the potential for treated wood in the farm market. But, from discussion with lumber dealers, farmer organizations, lumber wholesalers, agricultural extension people, and others, it was felt that the potential was sizeable.

Test Market

Once the decision was made to concentrate efforts in the farm field, a test area was chosen to develop the most effective means of advancing the sale of treated wood to this field with a realistic budget. The test area, comprising the states of Indiana, Iowa, and Illinois, was chosen for several reasons.

In the first place, these states have high average income farms and farming is basically general, including both livestock and cash crops. They also are well covered with good media for all types of advertising. They were convenient, travel-wise. This was important because the test operation would require considerable traveling of sales, public relations, advertising, and market research personnel.

The first step was to determine the potential market in the test area and the form in which the preservative could be sold, if at all. This was accomplished in 1954 by exploratory trips through the test area. Spot checks

[1] Presented at Session IV, Marketing FPRS 10th National Meeting, June 4–7, 1956, in Asheville, N. C.

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were made with individual farmers, farm supply outlets of all types, county agents, and the state agricultural colleges.

The greatest immediate and easily realized potential appeared to be treated fence posts. There was no doubt that large quantities of fence posts were used each year. Most college estimates of the number of fence posts used annually were discounted as being unrealistic, since they included large quantities of home produced fence posts of naturally durable woods.

It was also apparent that the potential in home treatment of fence posts was unimpressive in the test area. In the forest areas, either durable woods were used for fence posts or non-durable posts with little or no home preservative treatment.

On the other hand, farmers in the better farming areas, who purchased their fence posts, were not interested in buying untreated posts and treating the posts themselves. They preferred to buy a fence post—whether steel, treated wood, or durable wood—that could be used without further work.

To develop a realistic potential for the test market, it was necessary to take into consideration the quantities of fence posts of all types that move through retail channels to the farm field. An estimate of the number of posts sold through retail outlets was taken as a realistic potential figure.

It was also found in this area that the words "pressure treatment" had a very definite sales advantage for fence posts. Because of this, the decision was made to base the test promotion on penta-pressure-treated fence posts.

The marketing of treated wood products was foreign to any of the company's previous operations, and it was necessary to determine the distribution channels through which such materials likely were to move most smoothly. Dow sells only the preservative to the treater and has no proprietary interest in the treated posts and poles themselves.

Method of Distribution

The distribution channels for treated posts varied somewhat from state to state. They included elevator chains, farmers' cooperatives, combination grain, lumber, and fuel outlets, and retail lumber yards. The lumber yards seemed to be best equipped to handle farmers' fencing needs.

Retail lumber yards generally purchase their forest products from a lumber wholesaler who may or may not have a connection with a treating plant or from an organization which combines a lumber producing and treating plant operation. In some parts of the test area, salesmen handling only treated wood called directly on retail lumber dealers.

Fortunately, the treated materials moving into the test market area came from areas in which were located treating plants equipped to treat with penta and also equipped to satisfy the farm demand for posts, small poles, and some treated lumber.

From experiences in other fields, it was recognized that no program would be successful unless it insured cooperation at all levels in the chain of distribution. Consequently, the overall promotional program was broken down for four different groups: farmer, retail dealer, wholesaler, and treating plant.

The farm program was designed to develop farmer interest and direct him to his logical sources of supply. It included national magazine advertising, sectional magazine advertising, sectional radio advertising, movies for farm groups, contact with farmer influence groups, and detailed publicity work with editors of all types of farm publications moving into the area.

The program to retail dealers consisted of steady direct mail, appearances on dealer association district meeting programs, exhibits at state lumber dealer conventions, publicity in dealer publications, and a movie for dealer use.

The program to wholesalers consisted of direct mail aimed at keeping them abreast of developments in the program and close personal contact both at sales meetings and in the field to give them the complete picture of the promotional activities, the goals, the advantages, and the effect on their personal profit picture.

For practical purposes, the treaters were given a program similar to that given the wholesalers with variations depending upon the treater's scope of activity and his approach to reaching this particular market.

Timing was, of course, important; and the treaters were obviously contacted first so that they might be cognizant of the possible effects on their inventories so that there would not be shortages at the treater level. Then the programs to the farmer, the dealer, and the wholesalers were implemented at approximately the same time. Wholesalers were given primary attention so that there would be no resistance on their part if a dealer asked for a shipment of the new treated materials.

After the program had been in effect for a year, a spot check was made to determine results, which were gratifying. For example, since the inception of the penta marketing program oriented toward the farm market, the sale of penta treated materials in Indiana has increased from nothing to approximately 35 per cent of the treated post and pole market.

Total Market Increased

This success story, although partially at the expense of other preservatives, has increased the total market for treated wood products. The market for treated poles and posts in Indiana, for instance, has increased at least 25 per cent since our program began.

A great deal of work was done by some of the merchandising-minded treaters involved. Also, about this same time, a great amount of publicity and merchandising effort was placed on pole type building for farm use by many of the metal merchandising organizations. Farm management groups were also active in this field. It was soon apparent that a great deal of attention to the pole building field was in order. Some of the advertising mats, advertising copy, and publicity were adjusted to emphasize pole type building along with pressure-treated fence posts as the season rolled on.

As far as the treating plants were concerned, while the advent of the pole building offered a great potential new market, it did require some reorganization on their part on shipment methods. Formerly on railroad and utility contracts, especially, straight carloads on one size of product was common and shipping was no problem. For the farm market, it was now necessary for them to include a variety of poles and 2-inch-thick tongue-and-groove splash board material in direct dealer shipments, in addition to the variety of fence posts and corner posts.

This greatly complicated both procurement and inventory problems at the treating plant. Also, because of the nature of retail selling and the natural desire of retailers to hold inventories to their lowest workable minimums, speed of shipment was a great factor. Those treating plants who adjusted their operation to provide better service for retailers made by far the strongest gains in sales volume. At least one treating plant actually set up a railroad spur devoted to small stocks of the various size poles, posts, and tongue-and-groove splash board material so that a car could be shunted along the siding to pick up a few pieces from each stock pile, much in the manner of a super market.

In the Midwest area today, most carloads of treated material contain a wide variety of sizes and it appears that this will continue. Because of the great cost advantages of pole type construction, it was a natural development that this construction also should find

many commercial applications. However, most commercial builders are not familiar with farm building and vice versa. There is little exchange of ideas between the two fields, and the movement of pole construction into the industrial field on a broad scale was delayed. Late in 1954, attention was focused on commercial pole type construction through advertising and publicity in national magazines such as TIME and BUSINESS WEEK. The response to such advertising and publicity was outstanding. Inquiries, in turn, were passed along to the great number of pole building specialists that had grown up to satisfy the farm construction field. With the additions of commercial interest in pole buildings, great gains were made in this field during the latter part of 1955 and the pace is increasing so far this year.

As a result of the success in the original test market area, the program was expanded last fall to additional states incorporating the many ideas learned in the test area. The increased sale of treated wood products in the new regions is very encouraging and should approach the level of sales in the test area in time.

Because of the nature of the farm market, market development has proceeded by regions. Regional development has many advantages in a program of this type, the major one being the concentration of manpower and advertising. Another would be being able to avoid costly errors in approach by uncovering mistakes in one region and incorporating better methods in the next region. Another would be flexibility and being able to adjust to different types of agriculture in the various regions.

Unfortunately, at this time, new demands on the treating industry for utility poles because of telephone expansion and industrial and residential growth in former rural areas has had its effect on the supplies of poles suitable for farm and industrial pole building construction. As a result, deliveries are generally slow, and the failure of the treating industry to provide materials for this enormous growing market may definitely retard the broad general acceptance of pole type construction.

On the other hand, there is no supply problem with fence posts. There seems to be a good supply of posts available for pressure treatment, and the sale of pressure treated fence posts in the test area is growing quite rapidly.

Future Prospects

Looking ahead, many developments can be visualized in the use of treated wood which should increase the market for forest products. Pole building is only in its infancy for both farm buildings and commercial sheds and warehouses. These low cost buildings are capable of making great inroads into conventional masonry, brick, or block construction; and, consequently, treated wood is recapturing markets which had been lost to other building materials. Sales of treated lumber used for pole type construction are expected to show a great growth rate in the years ahead.

The sale of treated fence posts also is recapturing a wood market which had been partially lost to steel. Many farmers had turned to steel because untreated wood posts often rotted out after five to ten years. This trend is being reversed. Also, with the greater availability of treated posts, many farmers are switching from the use of non-durable local species to pressure-treated posts.

In addition to the growth of treated posts and poles, there is an increasing demand in the farm market for treated dimension lumber for use in farm buildings and farm houses. Treated tongue-and-groove splash boards are often being used in conjunction with pole buildings, and there is a growing trend toward the use of treated dimension lumber elsewhere on the farm.

Conclusion

The results from the test area indicate that a sound merchandising program can effectively, substantially, and economically speed the consumption of treated wooden products by the farm and commercial construction industries.

A New Method for Testing Treated Wood Specimens[1]

GUSTAV G. KLEM

Norwegian Forest Research Institute, Vollebekk, Norway

For four years the NFRI has tested an "upon the ground" wood specimen test method. Stakes are placed flat so the entire under surface is in contact with the soil. Advantages are: sample less apt to dry out, saves labor, rot attacks stakes rapidly, allows for easier study and return to exposure plot, greater exposure area, and easier to collect rot samples.

Introduction

THE EFFICACY of a wood preservative may be determined by laboratory, greenhouse, or field testing. Of these, laboratory tests bring the quickest results. Great care has to be shown, however, in applying laboratory results to practical conditions. The greatest advantage to using a laboratory test method is the opportunity it gives the investigator to judge whether or not a preservative deserves to be tested further. A number of investigations, e. g. on the toxic effect of the preservative on many fungi and insects, on its degree of leaching, etc., may be of great help in distinguishing a poor preservative from a good one, before a decision is taken to subject it to long-term field tests.

An advantage of investigations conducted in greenhouses, is that conditions are closer to those encountered in practice. Here, too, care is necessary in transferring the results obtained, to the various attacks of decay occurring under natural conditions.

Field Tests

What is left then is testing in the field, where test specimens are set in

[1] The idea for this method was developed during the author's stay at the Forest Products Laboratory, Madison, Wis., in 1952. Instrumental in forming the method was the author's examination of experimental field tests conducted at the laboratory, and his discussions with W. J. Hegge of the Division of Wood Preservation.

The Author: Gustav G. Klem was graduated at the Norwegian Forest College, graduating in 1927, and received a doctorate degree in 1934. He became a professor at the Norwegian Forest Research Institute in 1949, and presently is in charge of the Wood Technology division.

Fig. 1.—Test site for "upon-the-ground" method for studying rot attack.

Fig. 2.—Comparison of rot attack on a stake placed on the ground and a stake driven into the soil.

"graveyards" or test sites. This is the most reliable method, because it is closely similar to that employed in practice, but it is also the one that requires the longest time to produce results.

Lately a change has been made to smaller stakes on these test sites, stakes of lumber 2 x 4 x 23 inches instead of round poles of fencepost dimensions.

By using these stakes, samples of a suitable size and of the same dimensions are obtained. It is therefore, easier to control the wood quality of the stakes as compared with the fence posts, and simpler to eliminate possible factors that may make comparisons between the different preservatives more doubtful.

The specimens of wood are set with about half their length in the ground. They are inspected periodically, usually yearly, and the soil as a rule is removed to a depth of a few inches all around the stake, in order to determine the condition of the stake. Decay organisms usually attack test stakes at the groundline; however, in a compact soil the chief point of attack will occur within a limited area around the specimen, a few inches above and below the surface of the soil. At the same time the lower part of the specimen may be perfectly sound. On sandy soil where there is a sufficient supply of air, the rot often attacks the entire lower part below the groundline.

With the constant appearance of new preservatives to be tested, a large number of stakes are used, and it takes a fair amount of work to prepare the test stakes, put them in service, and to carry out subsequent inspections. Further, the removal of the soil around the stakes during the inspection is arduous and time consuming, and at times the method gives the investigator an inadequate area for inspection. For example, the view of the area attacked by rot may not be satisfactorily exposed by this method of inspection when the ground is covered by grass or where the soil is heavy or hard.

The entire stake might be removed from the soil for close inspection. This type of inspection, however, should be avoided, since the stakes are difficult to remove from heavy soils, and removal often allows the soil to crumble and partially fill the hole.

Above Ground Technique

In order to attain an experimental technique that would require less work and afford greater facilities for studying the rot attack, and at the same time provide a better opportunity for sampling the rot for cultivation, the Norwegian Forest Research Institute has for a period of four years tested a new method in comparison with the old one.

The new test method consists of placing the stakes "upon the ground" rather than setting them in the ground. The sample is placed flatwise, quite loosely, and to a depth of about ¼ in., so that its entire under side is in close contact with the soil surface. The sample is than less apt to dry out on its under side during dry periods (Fig. 1).

In comparison with the older method, the new one saves labor when setting out new samples. It appears that rot attacks stakes more quickly when they are set the NFRI way than it does when they are driven into the soil. This is the case with untreated samples, which after a period of four years have been so severely attacked by rot that several of them have been rejected.

The NFRI method allows the investigator to easily pick up each sample, study it, and return it to the exposure plot. If cleaner samples are necessary for closer examination, they are washed carefully with water. The area exposed to decay in the NFRI method is much greater (Fig. 2). Since the new method was started, the collection of rot samples for cultivation has been easier because a more extensive area of decay is available for the selection of samples.

The Norwegian Forest Research Institute plans to use this "upon the ground" method in the future, because it has proved far more efficient than the old method. The new method has also been tested, parallel to the old one, in greenhouse experiments where it has proved as satisfactory as it did in the field tests.

New Applications for Preservative Treated Wood[1]

ROBERT J. PRETTIE

President and General Manager, Northern Wood Preservers, Ltd., Port Arthur, Ont.

Many new markets holding great promise are opening up for preservative treated wood. The farm market is one major potential user. Applications in this and other such areas as marine structures, car decking, boardwalks, highway culverts, and factory flooring are pointed out.

Introduction

THE TREATING INDUSTRY used to look only to the railroad and the utility for business. The operation was simple as these major customers carried their own inventories and committed themselves to yearly programs. It called for a minimum of overhead and sales effort, so the treating service was priced accordingly.

But today a broad new market for pressure-treated wood is opening up down on the farm. Although there are fewer farm units, the trend is toward larger farms and bigger farm incomes, due to rapid advances in agricultural science and technology.

The spread of modern farming practices has led to an upsurge of interest in arrangements or equipment to reduce labor and develop structural designs that fit today's needs while offering economy of construction.

The use of preservative-treated timber on the farms offers a great challenge, and the need for increased sales effort as each buyer has to be sold individually.

Farm Applications

The development of the pole frame structure, offering flexibility, economy and simplicity both in construction and operation, is taking hold. The vertical members of the building are pressure treated poles. They are set in the ground at 12, 14 or 16 foot intervals as required. The horizontal members are bolted or nailed to these vertical poles,—then the sheeting and roofing is applied. The resultant structure is simplicity itself and can be put together with unskilled labor. It is extremely rigid. One of the larger buildings of this nature, 180 by 694 feet, erected near Baltimore withstood the whole force of Hurricane Hazel when other buildings nearby collapsed. This building will house 4,000 sheep or hogs and it required 820 pressure treated poles, 600,000 feet board measure of lumber and 137,000 square feet of corrugated roofing.

The pole frame building can be used with or without a floor. It is very durable, since the poles and the splash boards around the bottom are treated. Sometimes wooden sheeting is used and sometimes metal. This depends upon individual choice and local economy. The resultant building runs about half the cost of any other construction.

It makes an excellent building for housing and feeding cattle, fair ground pavilions, and storage of agricultural products, farm machinery, surplus equipment at a plant, used cars,—almost any purpose to which a building may be put.

Horizontal silos are gaining adherents because of lower construction costs and labor saved in handling silage by mechanical equipment. Cattle feeders and hay storage buildings are still further uses of pressure treated timber.

Fence posts offer a large market. Some 22,000,000 posts are now pressure treated annually in Canada and the United States. The vineyard post market has never been touched. Highway guard and guide rail posts and sign posts should be treated.

Marine Applications

The use of pressure treated foundation piling is gaining wider and wider acceptance as engineers and architects have found that the water table doesn't always remain constant over a period of years. If the water table recedes the foundation piling is no longer sealed off from the air and is consequently vulnerable to fungus attack. Failure of piling under a large and costly structure is just unthinkable so more and more pressure creosoted piling is now being specified for such purposes.

The composite deck bridge is an interesting example of combining pressure creosoted timber and concrete to provide an economical and durable structure. By a series of grooves, up lift spikes, steel shear developers and reinforcing steel, the concrete is practically welded to the timber. The treated timber is used under tension in the under part of the structure while the concrete is under compression and forms the floor. In recent years, this type of construction has also been used extensively for wharves on both the Pacific and Atlantic Coast.

Other Uses

Railways, particularly in the United States and more recently in Canada, have found that their car decking, which is nearly always made of wood, decays more rapidly than it wears out. In fact, the decay aids the wear and the wear advances the decay. Treatment with pentachlorophenol and petroleum has gained wide acceptance for this purpose and much-improved service life is apparent.

There are many unique applications for treated timber. Sidewalks and boardwalks at such places as Atlantic City and Toronto Island have been pressure treated. The new roller coasters at Crystal Beach and at the Toronto Exhibition were both pressure treated. In both cases the framing was carried out in the treating plant prior to treatment.

Many long flumes for transportation of water and timber products have been treated and have been giving satisfactory service. Creosoted wood stave pipe has been used extensively for carrying water for many years.

Creosoted wood stave pipe also has been used for highway culverts, storm sewers and ordinary waste sewers. The wood has a resilience to frost and to the shock of traffic which is not found in vitrified tile or concrete.

Creosoted wood blocks make the finest factory flooring available. It withstands shock. It is neither damaged itself nor are tools damaged if dropped on the floor. It is much easier on the workman yet it will outwear and outlast any other known factory flooring.

These and many other applications of preservative-treated wood make a mockery of the suggestion that the lumber industry is gradually vanishing; that pressed wallboards, concrete blocks, steel and aluminum sheeting and many other such modern advances are gradually supplanting the use of timber. Unquestionably there are changes in the use and demand but in the overall picture the demand is increasing steadily for treated wood products which can and should come out of our forest.

[1] Presented at the Eastern Canadian Section Meeting, March 1–2, 1956, in Toronto, Ont.

Around the World in Forest Products Research and Development

Philippine Forest Products Lab Reorganized

The Forest Products Research Institute of the Philippines was created by executive order to replace the Forest Products Laboratory and the Forest Products Research Section of the Bureau of Forestry. The Institute, attached to the University of the Philippines, is a semi-autonomous institution.

A Forest Products Research Board governs the Institute. It consists of the Director of the Bureau of Forestry and the Dean of the College of Forestry as ex-officio members, and three members appointed by the President of the University, one to represent the lumber industry, one to represent other forest industries, and one to represent the general public.

The newly expanded Philippine Forest Products Institute.

The Institute started off with a permanent staff of 124 persons of all grades, which is larger than the permanent staff of the former Forest Products Laboratory.

Other Developments Around the World

Australia

● To eliminate jamming of automatic docking saws in the middle of a cut, Saxton Timber and Trading Ltd., Licola, Vic., Australia, experimented to find a workable arrangement.

The first trial saw was based on the assumption that if the teeth of automatic dockers would cut just as fast as they grabbed, jamming would be eliminated. This meant that a large positive hook angle was required. A 36-in. diameter, 54-tooth saw was prepared, the teeth having a hook of about 40° (5/6 radius or 15 teeth on a 54-tooth saw), a front bevel of about 8°, and a top bevel of about 15°. The tooth set was 30 thou. (0.030 in.). The saw made little noise, and jamming in the cut was entirely eliminated.

The second trial saw reverted to a conventional peg-type cross-cut of the same diameter and with the same number of teeth as the first. The teeth were ¼ in. deep and had a negative hook of 18° (1/3 radius or 22 teeth on a 54-tooth saw) and a back angle of 26° (½ radius or 19 teeth). They were bevelled front and back and the set was 35 thou. This saw made more noise than the one with the positive hook, occasionally jammed in the cut, and required sharpening earlier. It had the advantage of being much easier to prepare. With the positive hook, extreme care was necessary when the teeth were stripped, sharpened, and set, to prevent excessive and dangerous grabbing.

Subsequent experiments showed that the back bevel was unnecessary and that a front bevel of 5–10° is adequate. Rather than file both front and back bevel and turn the saw round when one side was worn, the saws were filed more often and only one bevel was maintained. The saws rarely jammed in the cut, and they sawed approximately 40 tons of foot blocks per sharpening. The machine has a stroke of 41 in. and operates at 40 strokes per min. It is driven from a 30 h.p. motor which simultaneously drives a hand-operated pendulum docker.

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England

● Results of work for the year 1956 have been compiled by the Director of the English Forest Products Research Board in a pamphlet entitled "Forest Products Research 1956".

The booklet contains summaries and illustrations about the various phases of activity and research carried on in 1956 at the English Forest Products Research Laboratory. The report is available from the British Information Services, 45 Rockefeller Plaza, New York City for 95¢.

Scanning World-Wide Forest Products Publications

Japan

Studies on Lignin. XX. On the Dissociatable Group in Lignin. H. Ishikawa and K. Takaiti. Journal of the Japan Wood Research Society, V. 2, no. 4.

By applying the colloid titration on lignin isolated from *Cryptomeria* wood, it has been found that the dissociatable group of lignin consists of the phenolic hydroxyl group and carboxyl group, and that determination of the group gives different results depending on the isolation method of lignin. Also, the amounts of phenolic hydroxyl group and carboxyl group estimated from the colloid titration-curve of lignin, agreed intimately with the values measured by methylating with diazomethane and subsequently hydrolyzing the methylated lignin with alkali.

By estimating the non-conjugated phenolic hydroxyl group according to the method of Aulin-Erdtman, and measuring the guaiacylic hydroxyl group by the method of Adler et al., it has been concluded that the phenolic hydroxyl group of lignin consists of non-conjugated phenolic hydroxyl group (type I and type II) and partly of conjugated phenolic hydroxyl group (type IV, type V and type VI etc.).

Norway

The Influence of some Scandinavian Barks on Hardboard Properties. Arthur P. Anderson. Norsk Skogindustri, V. 11, No. 5, May 1957.

The preliminary laboratory experiments in this report indicated that both pine and spruce barks can be added in sizable amounts to wood in making acceptable hardboard. The use of pine bark, 50% in amount, produced the only acceptable board when no sizing agent together with no heat-treatment was used.

When the Scandianavian procedure for hardboard was used, which included the addition of small amounts of sizing agent, together with heat-treatment, both pine and spruce barks produced what appeared to be satisfactory boards. These results suggest that pine bark, in varying amounts, may be used as raw material, without the addition of sizing agents, if higher percentages of pine bark are maintained in the composition.

With spruce barks, irrespective of the quantity used, it appears that both sizing agents and heat-treatments are required to produce a product which will meet specifications. Birch bark, irrespective of method or treatment employed, as used here, did not produce an acceptable product.

Abstracts From Current World Literature

Wood Structure

Amos, G. L. Radial fissures in the early wood of conifers. *Australian J. Botany* 2, no. 1: 22–34 + 2 plates (1954).

In certain conifers, anatomical evidence suggests that young trees may become exposed to conditions conducive to collapse during late wood formation, causing partial collapse and radial cleavages in the early wood. Living ray cells are exposed to the cavity after cleavage. Different species show different responses conditioned by the anatomy and physiology of the ray parenchyma. The cavities fill with cellular tissue in radiata pine (*Pinus radiata* D. Don), with resin in Douglas-fir [*Pseudotsuga taxifolia* (Poir.) Britt.], and remain empty in white spruce [*Picea glauca* (Moench) Voss]. When a living protoplast is given free access to moist air, a powerful growth stimulus is applied to the cell. In radiata pine, ray parenchyma cells have primary walls only, and the response is a proliferation of these cells. In Douglas-fir and white spruce, the ray parenchyma has secondary thickening and small ray tracheid pitting, precluding growth. The response is an increased metabolic rate, producing resin in Douglas-fir (heartwood-forming species) and without solid end products in white spruce (species with little contrast between sapwood and heartwood). [Bul. Pap. Chem. V. 27, No. 7]

Pulpwood

Clark, Donald H. Availability and cost of Pacific Northwest native hardwoods. *Tappi* 40, no. 1: 130-3A (Jan., 1957).

The wide availability and moderate cost of red alder and other Northwest Pacific hardwoods offer no present problem to the pulpwood industry in the state of Washington. No future problem is likely to arise if forest-land owners carry out proper reforestation policies. The present available volume of sawlog-size hardwood timber is 4202 million board feet: 70% red alder, 17% bigleaf maple, and 13% black cottonwood. A conservative estimate of the standing pulpwood material, not counting sawlog timber, is 12,600,000 cords. The actual present availability of pulpwood, based on sound forest management, is figured at 315,000 to 425,000 cords annually, considerably above the 313,000-cord annual usage estimated for the near future. The average present cost of delivering hardwood to the pulp mill is $14.00/cord. The author also describes current hardwood logging methods, pulpwood users' specifications for whole and pealed logs, data on volumetric purchasing standards, the possible use of sawmill residues and forest thinnings as pulpwood, and possible logging economies by chemical debarking of standing timber. [Bul. Pap. Chem. V. 27, No. 7]

Barking

Gläser, H. Measuring bark-peel resistance in the bast-free barking of fibrous wood. *Holz-Zentr.* 80, no. 95: 1–2 (Aug. 12, 1954). [In German]

The design, operation, and applicability of three instruments for measuring the bark-peel resistance of various trees are described. They include the Zieger peel-resistance meter, which is suitable for green trees with supple bark only, the wedge-type meter developed by the Max Planck Gesellschaft, and the Wilcox instrument devised at the State University of New York and manufactured by the Swedish company Sandvikens Jernverks Aktiebolag. The last-named device is superior to the Zieger instrument in that it permits measurements of peel resistance even on chemically debarked trees. [Bul. Pap. Chem. V. 27, No. 8]

Cell Structure

Nečesany, Vladimir. The nature of the so-called tertiary lamella. *Svensk Papperstidn.* 60, no. 1: 10–16 (Jan. 15, 1957). [In English; Swedish and German summaries]

The morphological and chemical character of the inner layer of the fiber cell wall (libriform wood fibers and tracheids) is discussed. Studies on the submicroscopic structure of cell walls in normal and in reaction wood are described, and results obtained with metachromatic dyeing are given. Knowledge gained on the decomposition of cell walls by wood-destroying fungi is also indicated. It is concluded that the inner layer is an inseparable part of the secondary wall and cannot be regarded as a morphologically distinct component. From this point of view, it can never be designated as a "tertiary lamella." It consists of cellulose and is strongly lignified in normal wood but insignificantly in hardwood reaction wood. In softwood reaction wood, the inner layer is usually missing. [Bul. Pap. Chem. V. 27, No. 7]

Programing

Practical linear programing applications. H. T. Schwan. *Industrial Quality Control*, Vol. 12 No. 9, March 1956, pp. 4–8, tables.

Linear programing assists management to make decisions based on facts related to the total problem rather than the various parts of the problem.

This system has already been applied with success to determine the most profitable manufacturing program, the effects of changes in buying and selling prices, whether to make or buy certain parts, the most profitable range of products, the best location of plant and warehouses and the lowest cost machine or manufacturing schedule. It is almost impossible to keep in perspective the many factors affecting decisions of this kind without the aid of some kind of formulation.

Linear programing is a five stage process which helps the management to organize the facts and information about a problem, analyze possible alternative solutions, select the best course to follow under given conditions, to plan the steps required and to re-evaluate the plan when conditions change. [F. D. C. Tech. Bul. V. 6, No. 34]

Finishing

Lignolac fire-retarding wood finishes. British Paints Ltd.

Resistance to combustion has already proved to be of value in the finishing of furniture for ships, railways and other forms of transport.

These finishes can be applied over any conventional stain or staining filler and their drying intervals are similar to the equivalent nitro-cellulose. When submitted to the Schults Test it was found that the finish burned only while the source of the flame was in contact with it and that there was no 'flame-spread.'

It should be noted that the term 'fire-retarding' refers to the lacquer in its final dry film state and that in liquid state it is still subject to the requirements of the Petroleum Act and Cellulose Solution Regulations. [F. D. C. Tech. Bul. V. 6, No. 35]

Foreign Woods

Muchenche (Newtonia buchanani). Uganda Forest Department Leaflet No. 27.

Muchenche, growing in Uganda, has a straight cylindrical bole giving logs of 30–60 ft. in length frequently in peeler form.

The color of the wood varies from pink to pinkish brown with a pronounced yellow tinge when freshly cut. The sapwood, varying from 2–6 in. in width is pale but not clearly defined from the heartwood. The grain is interlocked giving striped figure when quarter-sawn and the texture is coarse. Average weight at 15% m.c. is between 29–40 lb. per cu. ft.

It is a poor bending wood and needs careful stacking during seasoning to avoid warping, with some checking to be expected. It is susceptible to borer and termite attack; the heartwood is resistant to pressure impregnation. The timber works fairly easily by hand but machine mortising is difficult. Providing the grain is prefilled it stains and polishes satisfactorily but does not glue well. It is suitable for general joinery, utility furniture and plywood manufacture. [F.D.C. Tech. Bul. V. 6, No. 32]

The preparation of abstracts from world literature in many languages is so highly specialized and costly that the Forest Products Research Society has no abstracting service of its own. For the abstracts in this issue of the JOURNAL the Society is indebted to the respective abstract journals indicated, from which they have been selected with the kind permission of the editors. Readers wishing information in addition to that given in these abstracts should consult the original articles referred to. Copies or additional information can not be supplied by FPRS or the abstract journal. The journals from which abstracts are published in this issue are as follows:

BULLETIN OF THE INSTITUTE OF PAPER CHEMISTRY, published monthly at Appleton, Wisconsin by the Institute of Paper Chemistry, subscription price $25 per year. This Bulletin publishes over 3,600 abstracts per year on subjects of interest to manufacturers of pulp, paper, fiberboard and allied products.

CHEMICAL ABSTRACTS, published semimonthly by the American Chemical Society, Executive Office—1155 Sixteenth Street, NW, Washington 6, D. C., subscription price $60 per year plus postage. This abstract journal publishes many thousands of abstracts annually with broad coverage of world literature in the entire field of chemistry and allied subjects.

TECHNICAL BULLETIN OF THE FURNITURE DEVELOPMENT COUNCIL is published bimonthly by the Council at 11 Adelphi Terrace, London W. C. 2, England. The Technical Bulletin publishes hundreds of abstracts and reviews from world literature annually, relating to the various phases of the furniture manufacturing industry. Subscription price is $5 per year.

Review of FPRS Section Meeting Papers

Structural Glue Laminating

Robert E. Eby, Chief Engineer Rilco Laminated Products, Inc., St. Paul, Minn. Upper Mississippi Valley Section Meeting, May 3, 1956, in Minneapolis, Minn.

Glued laminated structural members are being produced in ever-increasing numbers with new shapes and adaptations appearing almost daily. Straight, cambered, tapered and curved members are being used in a great variety of constructions.

Pressure treatment is usually done after gluing although treatment prior to gluing is in order when the shape of the member is such that it will not fit into retorts. The same design formulas, values for fastenings, and other criteria are applicable to glued laminated as to sawn lumber. The only difference is in higher allowable working stresses and in modification of these stresses when curved members are involved.

The production of structural glued laminated members requires close controls throughout the manufacturing process to assure a quality product. The basic controls are: 1) proper drying and structural grading of laminations; 2) accurate surfacing and cleanliness of lumber prior to gluing; 3) precise mixing and spreading of adhesives; 4) clamping and curing with strict control of pressures, temperature, and humidity; 5) machining, positioning, and gluing of end joints to assure the strength of end joints assumed in design; 6) locations of grades and scarf joints in accordance with design specifications; 7) accurate patterns and fabrication to assure sizes and framing in accordance with shop drawings.

Secondary controls include surfacing, patching, finishing, sealers, and wrapping. End joints may be pre-glued and set prior to laminating or may be glued and set during the lay-up and pressing operation. Normally, end joints are pre-glued for curved work and not pre-glued for straight work.

At our company, the laminating stock is first blanked to uniform thickness and width. The laminations then pass through an edge defect patcher which removes the defect in the upward stroke of a cutting head and inserts an inner-locking patch, matching the edge grain, in the return stroke of the cutting head. The ends are then scarfed to a 1-in-12 bevel with the scarf being cut by knives traveling along the scarf and parallel to the grain. This gives as smooth a gluing surface as is possible and a decided improvement over previous methods.

Immediately following the scarfing operation, joints are pre-glued in an automatic positioning high frequency machine and the full length lamination is then resurfaced to the final thickness. The full length lamination then moves immediately to the lay-up, through the glue spreaders, and into the presses. A superior joint is assured with this new method, and the chances of human error in production are greatly reduced. Production costs have also been lowered.

The quality control department consists of two wood technologists who devote their entire time to checking items such as glue mix and spread, moisture content, gradation, pressures, etc. Tests are made daily on production which include shear block tests, chisel test, cyclic delamination, etc. Responsible to management, they establish the quality of the product and the production department determines the procedures required to produce that quality.

Machining Tests for Hardboard

E. M. Davis, Forest Products Laboratory, Forest Service, U. S. Department of Agriculture, Madison, Wis. Northeast Section Meeting, Oct. 25–26, 1956, New York, N. Y.

Hardboard production has increased tenfold from 1939 to 1955. Output in 1955 reached 1¾ billion square feet on a ⅛-inch basis, equal to the Stanford Report estimate for 1962. Three of the 11 hardboard plants in the U. S. are expanding and nine new plants are being built.

The production process, specie, color, and other aspects vary among the more than one dozen brands on the market.

The furniture industry is the largest consumer of hardboard according to the latest figures. In 1952, furniture accounted for 325 million square feet or 32.5 per cent of total output. Manufacturing is second with 28 per cent, followed by construction, 22 per cent, and household, 17.5 per cent.

Machinability affects the utility of hardboard for many uses. Five types of hardboard were tested for machinability. Nine operations were covered in the tests.

Sawing—Pronounced differences in the sparking tendencies were noted, and minor differences in fuzzing and chipping at the sawed edges were noted. None of the boards thickened or burned.

Planing and sanding—A close thickness tolerance required to insure a good bond for laminating was obtained by planing or sanding the mesh side. Planing was smooth because of lack of grain. Sanding left visible scratch marks on the finer textured boards.

Shaping—The quarter-round pattern on the upped edges was free from fuzzing, but in the lower edge pattern, fuzzing ranged from moderate to heavy.

Routing—The general quality of work was poorer than that of the shaper. Degree of fuzziness depended upon the type of cutter. A down-cut spiral cutter was most effective, with the up-cut spiral producing edge thickening. The common 2-lip router bit was intermediate.

Grooving—Hardboards may be grooved for decorative effect for interior paneling. Some samples produced considerable fuzz. Good results were obtained when the cutter cleared away fuzz at the corners.

Jointing and Beveling—This may be done for chamfering hardboard or readying mismatch. The mesh side usually developed fuzz in lighter and coarser textured boards. A chamfer of 1/32 inch removed fuzz in all cases. Beveling at a 45-degree angle to the extent of producing a feather edge always produced fuzzing, but edges as thick as 1/32 inch remained clean.

Boring—Variance was less than in other operations. The machine bit made cleaner holes. Twist drills caused some fuzzing. The machine bit produced slightly more thickening.

Nailing—Boards bulged when nailed near the edge, and thickened around the nails or the nails bent when they were driven. Delamination occurred to some extent, and there was some bulging and shearing. Pre-boring is recommended.

The main problem is the rapid dulling of cutting tools, solved largely by use of carbide-tipped tools. Hardboard is less subject to machining defects than lumber. Fuzzing, chipping, and swelling were limited to newly machined edges.

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NEW PUBLICATIONS

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Gluing Untreated and Preservative Treated Red Oak at Fiber Saturation. William J. Finnorn. This study contains results of tests run to determine the gluability of steam bending stock at high moisture content. Products such as laminated railroad ties and utility poles were tested. Available from Timber Engineering Co., 1319 19th Street, N. W., Washington 6, D. C. Reprint from Wood Research.

California Coast Redwood. Compiled by Emanuel Fritz. This is an annotated bibliography to and including 1955 on the literature available on California Coast Redwood. Published by the Foundation For American Resource Management, 582 Monadnock Bldg., San Francisco, Calif.

Modular Co-ordination in Building. This report is based on studies carried out in 11 European countries, the United States and Canada. Divided into three parts, the report discusses design, manufacture and construction. It has 140 pages and is available for $1.50 from the Organization for European Economic Co-operation Mission, 2002 P Street N. W., Washington 6, D. C.

The Fibre Building Board Industry in Europe. The first study of fibre building board ever made at the European level. It has been prepared differ widely in their industrial structure and production methods and whose trade policies are therefore often diametrically opposed to each other. Available for $1.50 from the Organization for European Economic Co-operation Mission, 2002 P. Street N. W., Washington 6, D. C.

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